London Road, Bracknell
Berkshire RG12 2SZ

LONDON, METEOROLOGICAL OFFICE
Met.O.3 Technical Note No. 34

Homogeneity of U.K. climatological data 1901-1980.

8608 0550 FH4B

FGZ
National Meteorological Library and Archive
Archive copy - reference only

LONDON, METEOROLOGICAL OFFICE
Met.O.3 Technical Note No.34

Homogeneity of U.K. climatological data 1901-1980.

8608 0550 FH4B

AM

286

METEOROLOGICAL OFFICE
148618
C
LIBRARY

MET O 3 TECHNICAL NOTE NO 34

Homogeneity of U.K. Climatological Data 1901-1980

by

F A Crummay

3 8078 0002 2084 0

(This report has not been published. Permission to quote from it should be obtained from the Assistant Director of the Advisory Services Branch of the Meteorological Office).

Advisory Services Branch (Met O 3)
Meteorological Office
London Road
Bracknell
Berkshire
RG12 2SZ

May 1986

FH4B

Contents

Page

1	Summary
1	Introduction
2	Data
3	Method
5	Results
5	Discussion
6	Conclusion
7	References

Tables

1	Summary of results for temperature parameters in 30 year sections
2	Inhomogeneities identified in the total annual sunshine records for selected climatological stations 1901-1980

Figures

1	Residuals (Temp-mean) for max-min temperature
2	Residuals (Sun-mean) for sunshine
3	Summary of stations considered to conain a homogeneous period of data (excluding sunshine)
4	Inhomogeneities identified as occurring due to changes in thermometer screen

Summary

A modified version of the routine to monitor the homogeneity of monthly climatological data (Crummay, 1985) was applied to annual means of daily maximum and minimum temperature and maximum-minimum temperature for the period 1901-1980. Stations containing homogeneous sections within this period were identified and the genuine data from 1891-1980 for these climatological variables and total annual sunshine investigated to identify stations considered suitable to monitor climatic trends.

Introduction

The need to investigate climatological data before the calculation of long period averages or the selection of specific stations to monitor climatic change was discussed by Crummay (1985, 1986). A routine was described and used to study mean monthly maximum and minimum temperatures and total monthly sunshine for 577 stations between 1951-80. The majority of inhomogeneities identified consisted of gradual trends in the data for which corrections could not be made although some step changes were identified as a result of site changes.

Crummay (1986) considered that the nomination of specific 'Climatological Reference Stations' as defined by the World Meteorological Organisation (WMO, 1981), to monitor climatic trends, might result in the inclusion of unrepresentative inhomogeneities. Instead, two alternatives were suggested:

i. the calculation of regional series to monitor climatic trends, as developed by Manley (1974) and

ii. a thorough investigation into the homogeneity of stations for different time periods to assist in the construction of a composite series of data using individual station records which are considered representative for specific periods of time.

With reference to the latter, 22 stations were identified as suitable for the monitoring of climatic change in the period 1951-80 but the study period was constrained by the lack of machineable data prior to 1951.

In the following discussion the monitoring technique for monthly data has been modified to analyse annual means of daily maximum and minimum temperature, maximum minus minimum temperature and total annual sunshine for the period 1901-1980. The data is divided into thirty-year sections 1901-30, 1911-40, 1931-60, 1951-80 with the 1951-80 study used to compare the two analyses, that is, monthly vs annual data.

Those stations considered to contain a long period of homogeneous data will be investigated using the genuine data to identify any trends too small to be observed over 30 years but significant over 80 and inhomogeneities masked by the monitoring routine in areas with sparse data.

Data

Annual values for the climatological variables required are available in paper archives and the annual summaries of the Monthly Weather Review (MWR) after 1903, and from 1931, for selected stations in machineable form.

The stations at which observations of maximum and minimum temperature were recorded fall into two groups after 1921

i. Those that observe extremes for 24 hours terminating usually at 09Z or 21Z.

ii. Those that observe day maxima and night minima.

The terminal hours of both types of station have changed over the study period, for example, for day maximum temperature prior to August 1944 the thermometers were set at 07Z and read at 18Z in contrast to 09Z and 21Z after January 1945. These changes are considered relatively unimportant and corrections have not been applied. Several stations have however changed

the type of observation recorded, from 'day' maximum and 'night' minimum to 24 hour extremes. The values recorded may differ by up to 1°C for minimum temperatures at an inland site with the 'night' minima generally greater than the 24 hour minima and the 'day' maxima less than the 24 hour maxima. Corrections have been calculated using 38 stations in the period 1957-70 (Meteorological Office, 1975) comparing 24 hour extremes to 'day' maxima and 'night' minima terminating at 09Z and 21Z. The differences are most marked in winter but on an annual basis corrections of +0.15°C and -0.3°C have been applied to 'day' maximum and 'night' minimum temperatures respectively.

No inhomogeneities have been observed when the same corrections are applied to observations with an 07Z terminal hour.

Various other peculiarities occur within the data extracted, for example, differences in the type of screen used to shield the thermometers. The majority of stations consist of thermometers contained within a Stevenson Screen at a height of 4 feet above short grass. A few stations however employ the use of a 'North Wall' screen, frequently at a height of 10 feet. Examples include Kew Observatory, Falmouth and Stonyhurst and although of little significance if the screen remains constant throughout the study period, marked inhomogeneities may occur when the type of screen changes.

At Camden Square in London, a Glaisher stand was in operation until 1922. The thermometers were therefore not protected from indirect radiation, a feature which would influence the values recorded (Margary, 1924).

Method

As described by Crummay (1985) the monitoring technique involves the calculation of estimates of the variable using a Principal Component Analysis, the derivation of residuals (observation - estimate) and the subjecting of this time-series of residuals to statistical analysis to identify

inhomogeneities in the data record.

The decision to divide the study period into 30 year sections was based on the requirement of a complete correlation or covariance matrix for the 'Analysis'. Estimates of missing data were made using a near neighbour technique described by Tabony (1983) with the division into 30 year segments permitting the limiting of each study to stations containing at least 20 and preferably 25 years data in that segment. This improved the reliability of estimates produced both for the missing values and in turn, those for comparison with the observations.

Up to 100 stations were used in each 30 year period with the emphasis on complete records of data and a selection of station types such as rural and urban to facilitate the identification of trends due to urbanisation.

The limitation of using 100 stations in contrast to the 577 used for the monthly analysis influenced the optimum member of components selected to produce estimates. This optimum number should identify the systematic differences between the stations whilst random differences are consigned to higher order components and hence are illustrated by the residuals. The correlation between the stations is important with 8% of the total possible number of components used for monthly temperatures but 12% of the sunshine components due to the lower inter-station correlation. In the present study an analysis of stations flagged in the 1951-80 period in comparison to those flagged by the monthly routine determined that 14% of components should be used to produce the required estimates for temperature, a result of the lower correlation due to the greater distances between stations.

The marked variability in total bright sunshine recorded, the low correlation between stations and the fewer stations available precluded the identification of an optimum number of components for the annual data. As a result the sunshine data prior to 1951 was excluded from the analysis

although the genuine observations minus the station means were plotted for the long period stations.

Results

A total of 176 stations were investigated by the monitoring routine and the results for each 30 year segment illustrated in Table 1. Only 24 stations were considered to contain no inhomogeneities, the majority of these consisting of short period (ie 30 years) stations.

For the period 1951-80 the results have been compared with those obtained by the analysis of monthly data (Crummay, 1985). Some slight differences occur, with the monthly technique apparently more sensitive than that using annual data and flagging slightly more stations. There is generally good agreement between the two sets of results.

74 long period stations containing homogeneous sections were further analysed by an investigation of the genuine data over the eighty-year study period, the maximum-minimum values being illustrated in Figure 1. In addition 58 stations were analysed from 1891. Sunshine data was also investigated for these stations and the total annual sunshine minus the station mean for each station is illustrated in Figure 2. Again the level of 'noise' to a large extent prevents the detection of inhomogeneities but several major discontinuities and trends have been identified (Table 2).

A summary of the results obtained from the temperature analysis with the periods for which each station is considered homogeneous is provided in figure 3. This may be used in conjunction with Table 1 to identify long period homogeneous stations and assist in the selection of representative stations for specific purposes.

Discussion

The results obtained from the analysis of annual means of daily maximum and minimum temperature together with maximum-minimum temperature

and total annual sunshine again highlight the problems associated with the specification of individual 'reference stations' as discussed by Cummay (1985, 1986). Inhomogeneities may be attributed to any of four reasons:

i. step discontinuities due to changes in site location
ii. gradual trends due to changes in site exposure or character.
iii. deterioration of screen or instruments.
iv. small cumulative changes in site or varying accuracy between observers.

The majority of inhomogeneities consist of gradual trends for which corrections cannot easily be made. In addition a fifth possible cause has been identified in this study, that is, changes in the type of screen used. Examples include the change from a Glaisher Stand to Stevenson Screen at Camden Square in 1922; the change from a North Wall screen to a Stevenson Screen at Falmouth in 1912 and a change from a North Wall screen to a Bilham Screen at Stonyhurst (Figure 4).

As might be expected the longer the station record the greater the liklihood that at least one inhomogeneity will be observed in the data series. In the United States for example, Mitchell (1953) identified an average of 6 moves per station over the period 1873-1950. Although for other countries the average number of station site changes is considered to be much less (Jones et al, 1986), when the other sources of inhomogeneities are included it is apparent that almost every long period station has been affected at least once.

Conclusion

Crummay (1985) as a result of the monthly analysis of UK climatological data 1951-80 suggest two possible alternatives for the monitoring of climatic trends.

i. the calculation of regional series based on data from several stations to reduce the impact of any individual inhomogeneities.
ii. the construction of a composite series of data from sections of individual station records considered to contain representative trends for specified periods of time.

The annual study has investigated selected climatological stations from 1901-1980 in 30 year sub-sets and from 1891-1980 for those containing homogeneous sections. This facilitates the construction of a composite series as described above and with this aim a summary of the results obtained is provided (Figure 3) with stations considered homogeneous for specified periods indicated.

References

Crummay, F A	1985	'Monitoring the homogeneity of UK climatological data' Met O 3 Tech. Note No 32 and appendices (January 1986).
Crummay, F A	1986	'Monitoring the homogeneity of UK climatological data'. Met Mag v 115 pp 133-142.
Jones, P D et al	1986	'Northern Hemisphere Surface Air Temperature Variations: 1851-1984'. J of Climate and Applied Meteorology. Vol 25 pp 161-179
Manley, G	1974	Central England temperatures: monthly means 1659 to 1973. Q J R Met Soc 100, 389-405
Margary, I D	1924	'Glaisher Stand vs Stevenson Screen' Q J Roy Met Soc 50 pp 209-226
Meteorological Office	1975	'Maps of mean and extreme temperature over the UK 1941-70'. Climatological Memorandum No 73.

Mitchell, J M 1953 'On the causes of instrumentally observed secular temperature trends'. J Meteor. v 10 pp 244-261.

Tabony, R C 1983 'The estimation of missing climatological data', J of Climatology v 3 pp 297-31 .

World Meteorological Organisation 1981 Manual on the Global Observing System v 1. Geneva, WMO No 544.

Table 1 Summary of results for temperature parameters in 30 year sections

Key to Table 1

- \- station considered homogeneous using annual means.
- * station considered inhomogeneous using annual means.
- ○ station flagged as inhomogeneous for 1951-80 using monthly means.
- ( ) Inhomogeneity marginal
- blank Station not included in this study section.

STATION NAME	DCNN OR REF NUMBER	MAXIMUM TEMPERATURE				MINIMUM TEMPERATURE				MAX-MIN TEMPERATURE			
		01-30	11-40	31-60	51-80	01-30	11-40	31-60	51-80	01-30	11-40	31-60	51-80
Lerwick	0044		-	-	-		-	-	-		-	-	-
Baltasound	0088			-	*			-	⊛			(*)	-
Wick	0293	-	*	*	-	*	-	-	-	*	-	-	*
Stornoway	0425	*	-	*	⊛	-	-	-	⊛	-	-	-	*
Fortrose	0482		-	*	⊛		-	*	⊛		-	*	-
Fort Augustus	0575		(*)	-	-		-	-	-		-	-	-
Nairn	1008	*	(*)	-	⊛	-	-	-	⊖	-	-	-	-
Gordon Castle	1095	(*)	-	-	⊖	*	-	-	*	-	-	-	-
Braemar	1215	*	-	-	⊛	-	*	-	-	*	-	-	-
Balmoral	1226	-	*	*	-	*	-	-	*	*	-	-	*
Craibstone	1272			-	⊖			-	*			-	*
Aberdeen	1280	*			-	-			*	*			-
Dundee	1361	-	*	*	⊛	-	*	-	-	-	*	-	-
Arbroath	1393		-	-	⊖		-	-	⊛		-	-	*
Perth	1482		*	*	⊛		-	-	⊖		-	*	-
Leuchars	1577			-	⊛			-	⊛			-	*
Edinburgh - Blackford Hill	1646		-	-	⊛		-	-	⊛		-	-	-
North Berwick	1678			-				*				*	
Marchmont	1744	*			⊛	-			(*)	*			-
West Linton	1838	-	*	-	-	*	-	-	-	(*)	-	-	-
Cockle Park (Morpleth)	2084	*	-	*	*	-	-	-	⊖	*	*	-	-
Tynemouth	2091		-	*	-		-	(*)	⊛		-	-	-
Chopwellwood	2138				⊛				⊛				-
Durham	2165	-	-	*	-	-	-	*	-	-	-	-	-
York	2261	-	-	-		-	-	-		-	(*)	-	
Scarborough	2292	-	-	-		-	-	-		*	-	-	
Hull	2361	*	-	-	⊖	*	-	-	-	-	-	-	-
Cranwell	2432			-	(*)			-	⊛			-	-
Cleethorpes	2478			-				-				-	
Skegness	2494			(*)	-			-	(*)			-	*
Cromer	3069			*	-			-	*			-	-
Yarmouth (Gorleston)	3093	-	-	(*)	⊛	-	*	*	-	-	-	-	*
Lowestoft	3197	-	-	-	⊛	-	-	-	-	-	-	-	-
Cambridge (Bot. Gar.)	3253	-	-	-	-	*	-	-	-	-	-	(*)	*
Woburn	3414	-	-	-	⊛	-	-	-	⊛	(*)	-	-	-
Rothamsted	3537	-	-	-	-	-	-	-	(*)	*	-	-	(*)
St Albans	3544			-	-			-	-			-	-
Shoeburyness	3671			(*)	-			(*)	(*)			*	(*)
Huddersfield	4041			(*)	-			-	-			*	-
Huddersfield (Oakes)	4043			-	-			-	-			-	-
Bradford	4045		-	-	⊛		-	-	(*)		-	-	-
Ilkley	4047	-	-		-	*	-		⊛	*	-		-
Sheffield	4061			-	-			-	⊖			-	-
Buxton	4112	*	-	-	-	*	-	-	-	*	-	*	-
Belper	4164	*				-				-			
Nottingham	4223	-	-	-	-	-	(*)	-	-	-	-	*	-
Edgbaston	4406	-	-	-	(*)	-	-	-	-	-	-	-	-
Coventry	4477	-				-				-			
Oxford	4522	*	(*)	-	-	-	-	-	-	*	-	(*)	-
Shrewsbury	4746			(*)	(*)			-	⊖			-	-
Newport (Salop)	4787			-	-			-	-			-	-
Malvern	4813				⊛				⊖				-
Ross-on-Wye	4882	*	*	-	-	-	-	-	-	*	-	-	-
Kensington Palace	5025		-	-	-		-	*	-		-	-	-
Hampstead	5028			-	-			-	-			-	-
St James' Park	5034				-				-				-
Camden Square	5038	*	(*)	*		-	-	-		-	-	-	

STATION NAME	DCNN OR REF NUMBER	MAXIMUM TEMPERATURE 01-30	11-40	31-60	51-80	MINIMUM TEMPERATURE 01-30	11-40	31-60	51-80	MAX-MIN TEMPERATURE 01-30	11-40	31-60	51-80
Wisley	5237	-	-	-	⊛	-	-	-	*	-	*	-	-
Kew (NWS)	5259	-	-	-	-	-	-	-	-	-	-	*	-
Croydon (Waddon)	5287			-	-			-	⊖			-	-
Addington	5297		*		-		*		-		-		-
Tunbridge Wells	5321	*				-				-			
East Malling	5336			-	-			-	-			-	-
Dungeness	5370	-				*				-			
Wye	5375			-	-			-	-			-	-
Dover	5390			-				-				-	
Margate	5399	*			-	-			-	-			*
Bognor Regis	5411	-		-	*	-		*	⊖	-		-	-
Worthing	5431	-	-	-	-	-	-	-	-	-	-	-	-
Hastings	5490			-	-			-	-			*	-
Shinfield	5575			(*)	-			(*)	-			-	-
Reading (University)	5578	*				-				-			
Southampton (E.Park)	5643	-	-	-		*	-	-		-	-	-	
Ventnor (Hosp + Park)	5771	-			-	-			*	-			-
Sandown	5790		-	(*)	⊛		*	-	⊛		-	-	*
Ryde	5798			-	-			-	⊛			-	-
Larkhill	5863			-	-			-	-			-	-
Boscombe Down	5872			-	(*)			-	⊖			-	-
Marlborough	5877	-			-	-			-	-			-
Tiree	6007			(*)	-			*	-			*	(*
Greenock	6318		-	-	⊛		-	-	⊖		-	-	-
Paisley	6366		-	-	-		-	-	(*)		-	-	-
Colmonell	6505	-				*				*			
Dumfries	6641	-	-	-	(-)	-	-	-	-	-	-	-	-
Eskdalemuir (L Hut)	6678		-	(*)			-	-			-	-	
Glenlee	6745				-				-				-
Douglas	6951	-	(*)	(*)	-	-	(*)	*	⊛	-	-	*	-
Newton Rigg	7071	-	(*)	-	-	(*)	(*)	-	-	*	-	-	-
Southport	7223	-	-	*	⊛	-	-	-	⊖	*	-	*	-
Morecombe	7239			-	⊖			-	-			-	-
Darwen	7266		(*)	*			-	-			-	-	
Stonyhurst	7269	-	-	-		(*)	-	(*)		*	-	-	
Liverpool (Bidston)	7307	-	-	-		*	-	-		-	*	-	
Macclesfield	7384	*	-	-	⊖	-	(*)	-	-	*	-	-	(*
Rhyl	7408	-	-	-	-	*	(*)	*	*	-	-	-	-
Hawarden Bridge	7467	(*)			-	*			*	-			-
Holyhead/Valley	7511	(*)	-	*	*	-	-	-	⊖	-	-	*	-
Aber	7768			-	-			-	-			-	-
Llandudno	7798	-	-	-		-	-	-		-	-	-	
Aberystwyth (1)	8056			-				-				-	
Aberystwyth (2)	8058			(*)				-				-	
Haverfordwest	8154		*	-			-	-		*		-	
Swansea	8413				-				-				-
Cardiff	8492	-	(*)	(*)	-	-	-	-	-	-	-	*	-
Weston Super Mare	8648	-				-				-			
Long Ashton	8678			-	-			-	-			-	-
Bath	8698	-	-	(*)		-	*	-		-	-	-	
Shaftsbury	8768				-				-				-
Mt Batten	8811			-	*			-	⊖			-	-
Plymouth Hoe	8812	-				-				*			
Ilfracombe	8829	-	-	-	-	-	-	*	-	-	-	-	(*
Torbay (Torquay)	8864	-			-	-			-	-			-
Teignmouth	8871	*	-	*	-	-	-	-	⊛	*	-	-	-

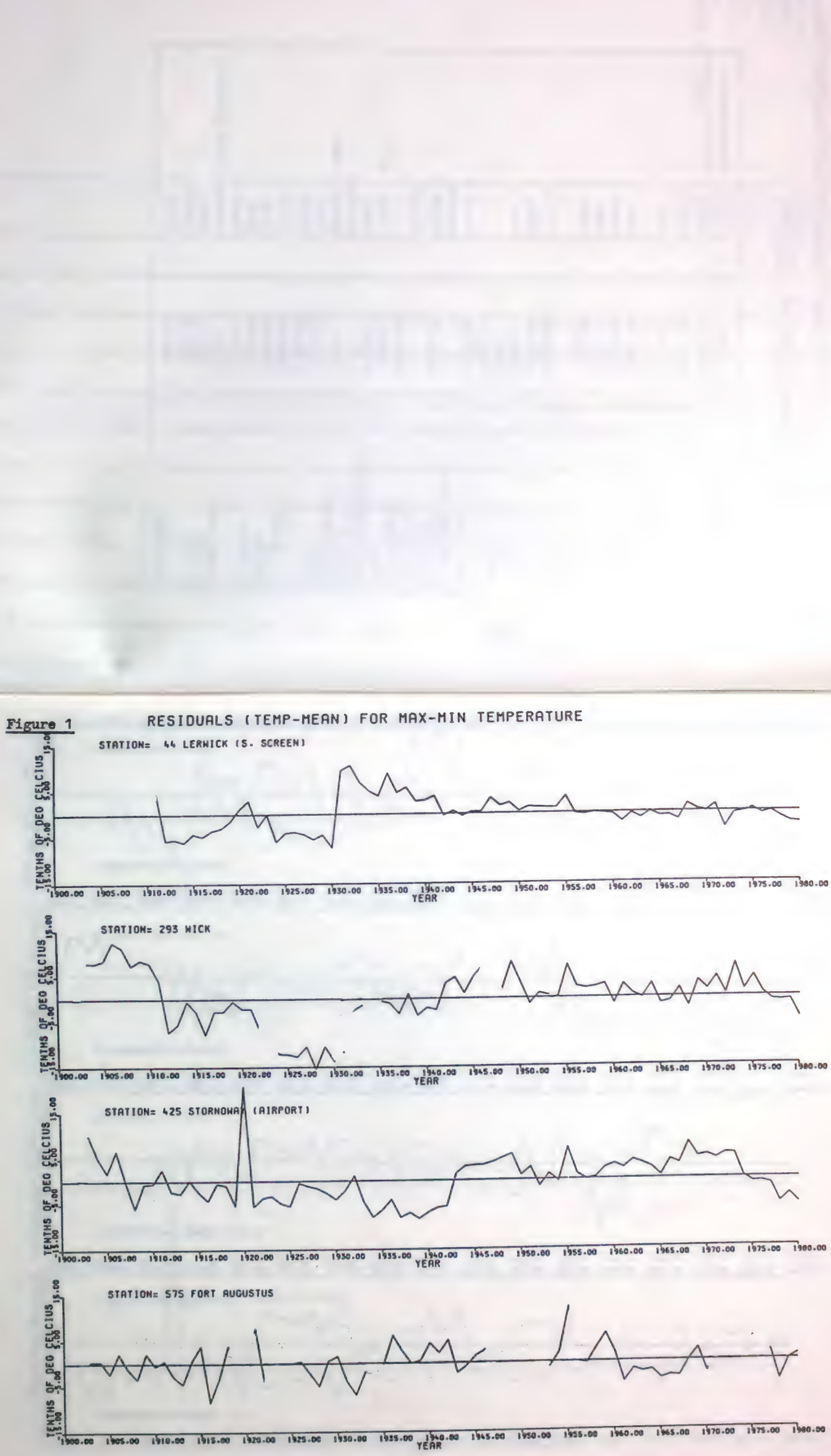
STATION NAME	DCNN OR REF NUMBER	MAXIMUM TEMPERATURE 01-30	11-40	31-60	51-80	MINIMUM TEMPERATURE 01-30	11-40	31-60	51-80	MAX-MIN TEMPERATURE 01-30	11-40	31-60	51-80
Exmouth	8881			-	*			-	*			-	-
Sidmouth	8891	-				-				-			
Scilly	8902	-	-	*	*	*	-	-	⊛	-	-	*	-
Penzance	8913	*			-	-			⊛	-			-
Gulval	8915			(*)	-			*	(*)			-	-
Falmouth	8942	-	-	*	-	-	*	-	-	*	-	-	(*)
Newquay	8946	*	-	-	(*)	-	-	-	-	-	-	-	-
Fowey	8971				⊛				⊖				-
Aldergrove	9142			-	-			-	-			*	-
Hillsborough	9238			*	(*)			(*)	-			-	-
Armagh	9336	-	-	-	⊛	*	(*)	-	-	-	-	-	-
Kelso	9901		-	-			-	*			-	*	
Rothesay	9902	-	-	-		-	-	-		-	-	-	
Deerness	9903	-	-			-	-			*	-		
Kettins	9904		*				-				-		
Montrose (Asylum)	9905		-				-				-		
Crieff	9906	-	-			-	*			*	-		
Wolfelee	9908		*				-				-		
Cardross	9910		-				-				-		
Dungavel	9911		*				-				-		
Thorntonhall	9912	-	-			-	-			-	(*)		
Ruthwell	9913		*				*				*		
Strathpeffer	9916	-				-				-			
Spurn Head	9923	-				-				*			
Lincoln	9924	-				*				(*)			
Geldeston	9925	-				*				*			
Bennington	9927	*				-				*			
Berkhamsted	9928	-				-				-			
Harrogate	9929	-	-			*	*			*	-		
Cheadle	9930	-				-				-			
Norwich	9932	*	-			-	-			*	-		
Copdock	9933		-				-				*		
Halstead	9934		-				-				-		
Meltham	9936	-	-			*	-			-	*		
Belvoir Castle	9938	-	-			*	-			(*)	-		
Oundle	9939		-				-				-		
Sparkhill	9940		-	(*)			*	-			-	*	
Rugby	9941		-				-				-		
Mayfield	9942		-				*				-		
Hereford	9943	*	-			*	-			-	-		
East Ham	9944		-				-				-		
Tottenham	9945	-	-			-	-			*	-		
Eastbourne	9946	(*)	-			-	-			-	-		
Totland Bay	9947	-	-			-	*			*	-		
Brighton	9948	*	-			-	-			-	-		
Portsmouth	9951	-				-				(*)			
Scaleby	9953	-				-				-			
Blackpool	9954	-				-				-			
Keswick	9955		*				-				-		
Burnley	9956		-				*				-		
Lancaster	9957	-	*			*	-			*	-		
Manc. (Whitworth Park)	9958	-	*			-	-			-	-		
Manc. (Oldham Park)	9959	(*)	-			-	-			-	-		
Hoylake	9960	-	-			-	*			(*)	*		
St Ann's Head	9961	*	-			-	-			-	-		

STATION NAME	DCNN OR REF NUMBER	MAXIMUM TEMPERATURE				MINIMUM TEMPERATURE				MAX-MIN TEMPERATURE			
		01-30	11-40	31-60	51-80	01-30	11-40	31-60	51-80	01-30	11-40	31-60	51-8
Arlington	9962	-	-			-	-			*	-		
Barnstaple	9963		-				-				-		
Cullompton	9964	-	-			-	-			-	-		
Woolacombe	9965	-	-			-	-			-	-		
Redruth	9966		-				-				-		
Ashburton	9967	-				-				-			
Jersey	9968	-				-				-			
Donaghadee (C. Down)	9969	-				-				-			

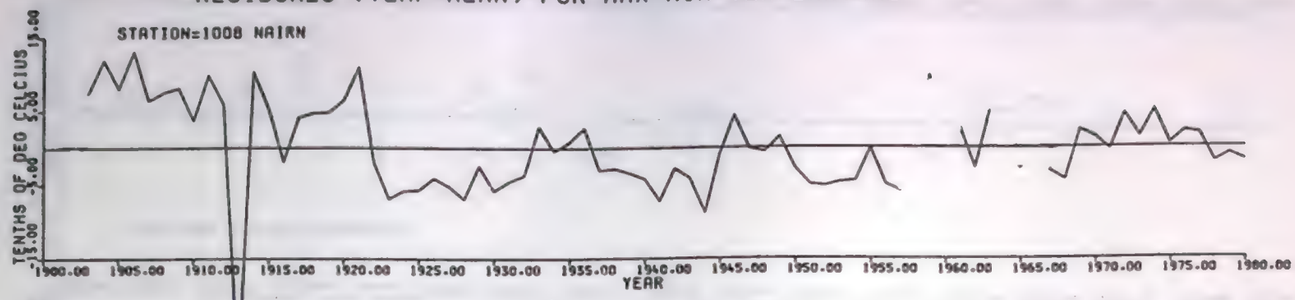
Table 2 Inhomogeneities identified in the total annual sunshine records for selected climatological stations 1901-1980

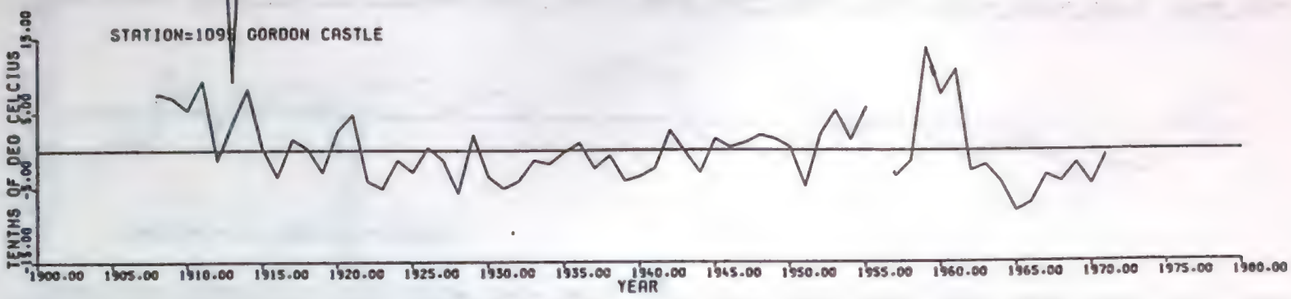
Station	Dates	Type of inhomogeneity
Wick	1945-80	Trend
Fort Augustus	1947-55	Step
Edinburgh (Blackford Hill)	1957-58	Step
York	1905-45	Trend
Hull	1925/7	Step
Lowestoft	1903-80	Trend
Woburn		
Rothamsted	1950-80	Various
Buxton	1907-72	Trend
Edgbaston	1927/8	Step
Wisley	1925	
	1947	
Kew (NWS)	1906-76	Trend
Tunbridge Wells		Various
Greenock	1937-75	Trend
Southport		Various
Stonyhurst	1907-29	
Rhyl	1903-73	Trend + step?
Valley/Holyhead	1924/5	Step
Cardiff		Various
Long Ashton	1950	Settled down
Bath	1916-20	Step
	1920-40	Trend
Ilfracombe	1930-50	Trend
Scilly	1923-24	Step
Falmouth	1947-49	Step
	1949-65	Trend
Aldergrove	1960	Becomes more variable
Armagh	1957/9	Step
	1959-80	Trend
Rothesay	1948-51	Step

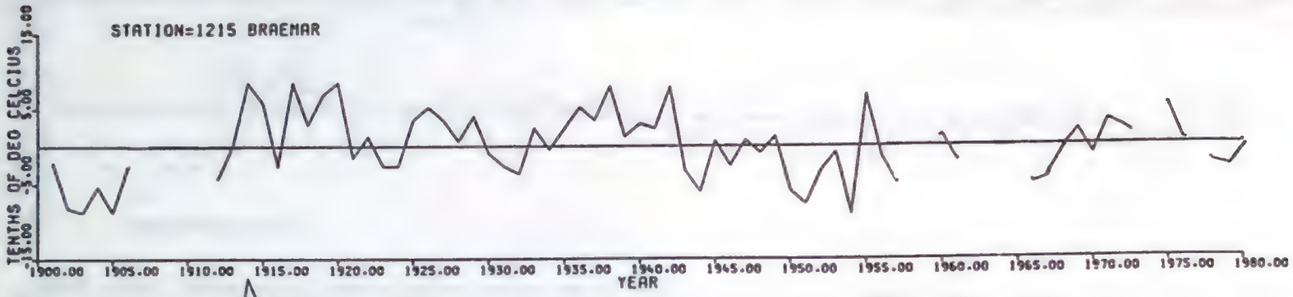
Figure 1

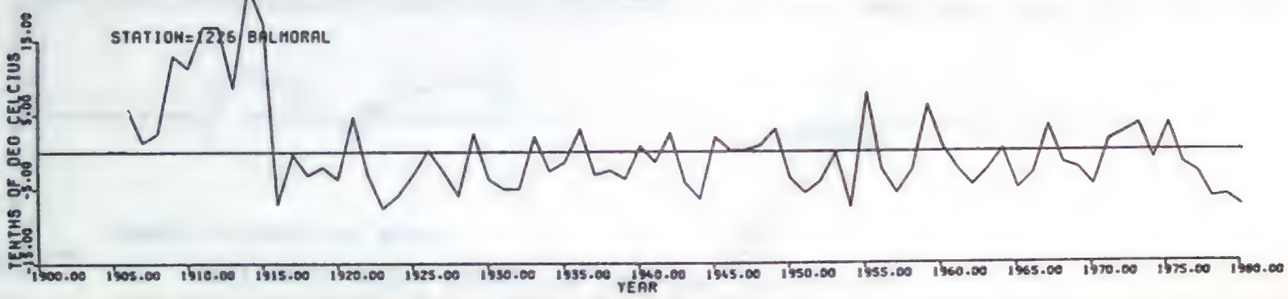

RESIDUALS (TEMP-MEAN) FOR MAX-MIN TEMPERATURE
STATION= 44 LERWICK (S. SCREEN)
STATION= 293 WICK
STATION= 425 STORNOWAY (AIRPORT)
STATION= 575 FORT AUGUSTUS
TENTHS OF DEG CELCIUS
YEAR
1900.00
1905.00
1910.00
1915.00
1920.00
1925.00
1930.00
1935.00
1940.00
1945.00
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00

RESIDUALS (TEMP-MEAN) FOR MAX-MIN TEMPERATURE

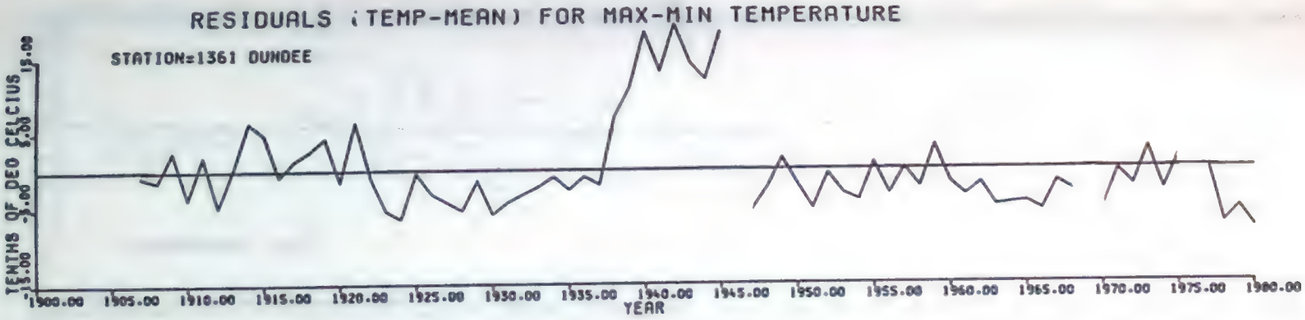


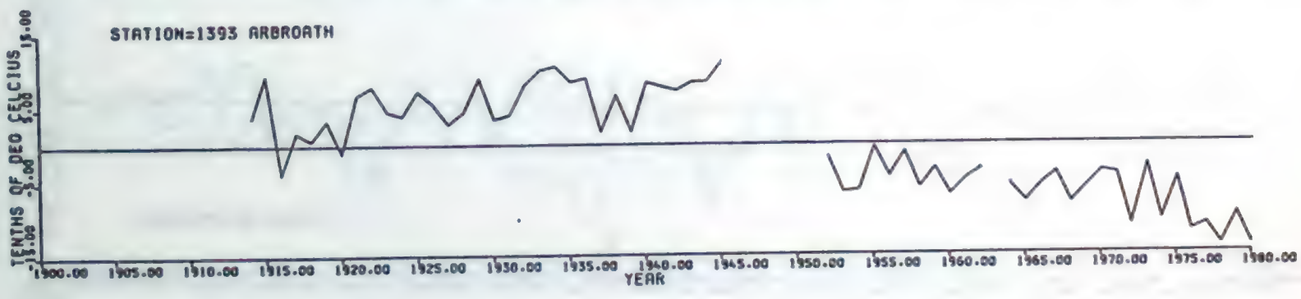


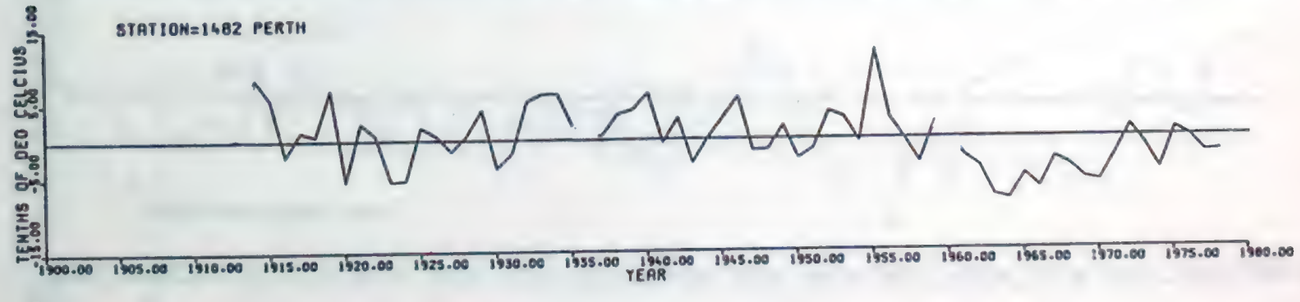


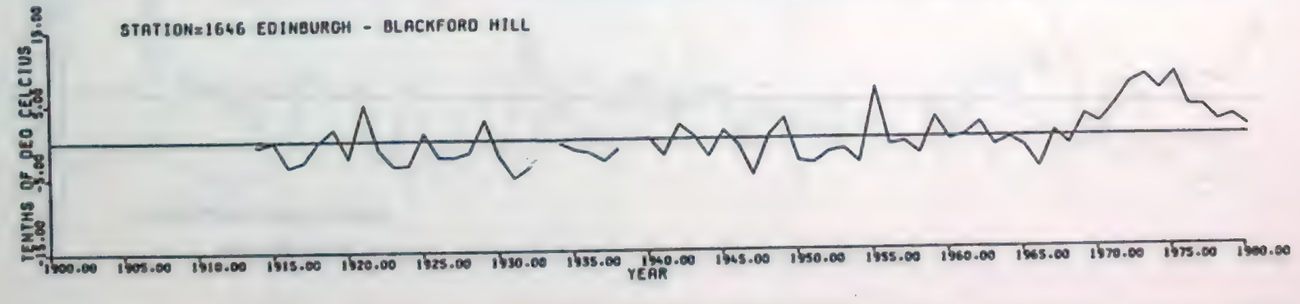


RESIDUALS (TEMP-MEAN) FOR MAX-MIN TEMPERATURE

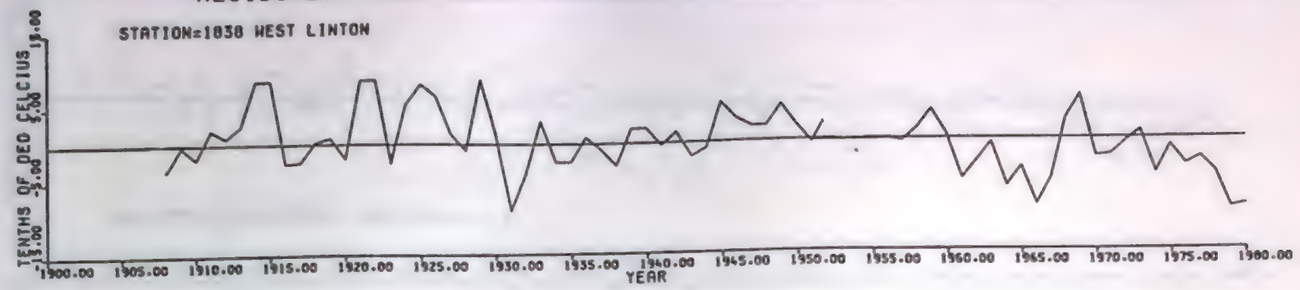


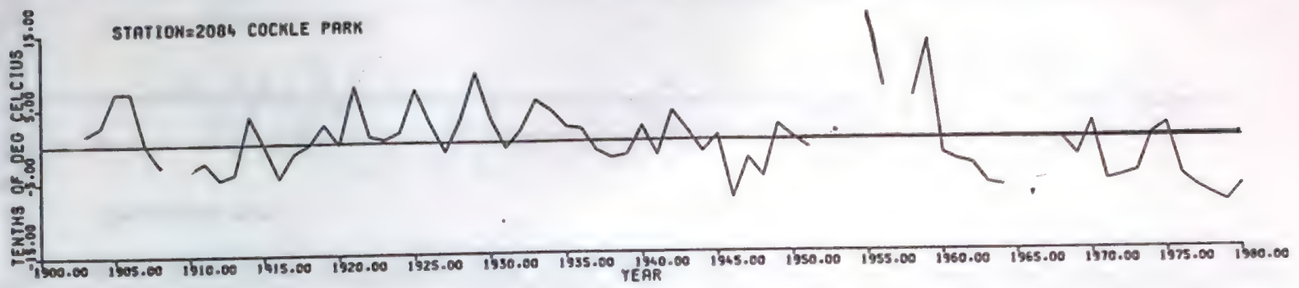


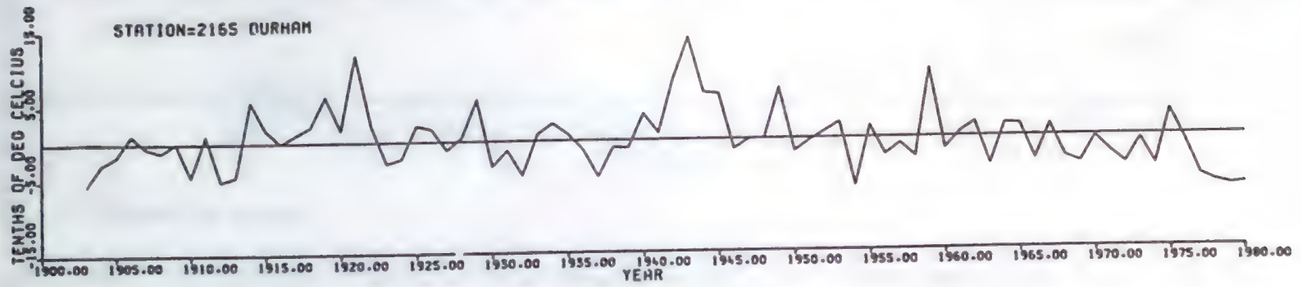


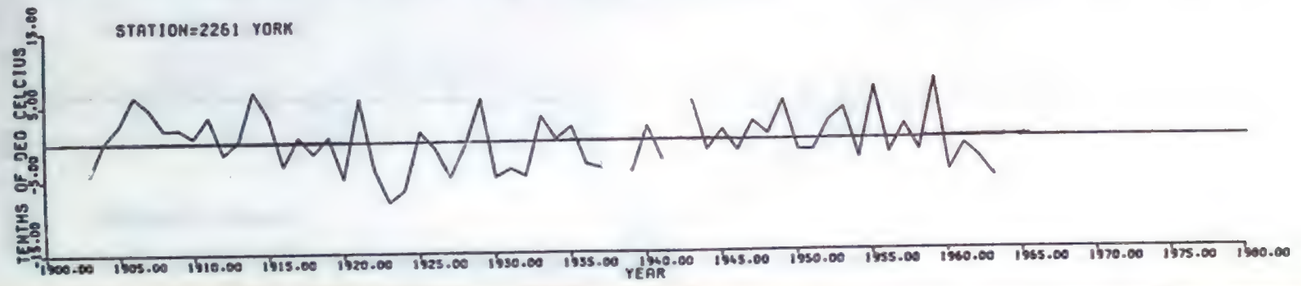


RESIDUALS (TEMP-MEAN) FOR MAX-MIN TEMPERATURE

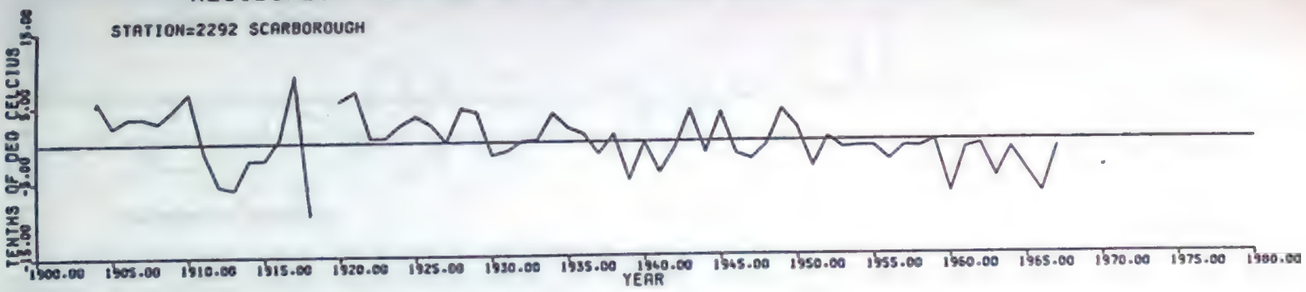


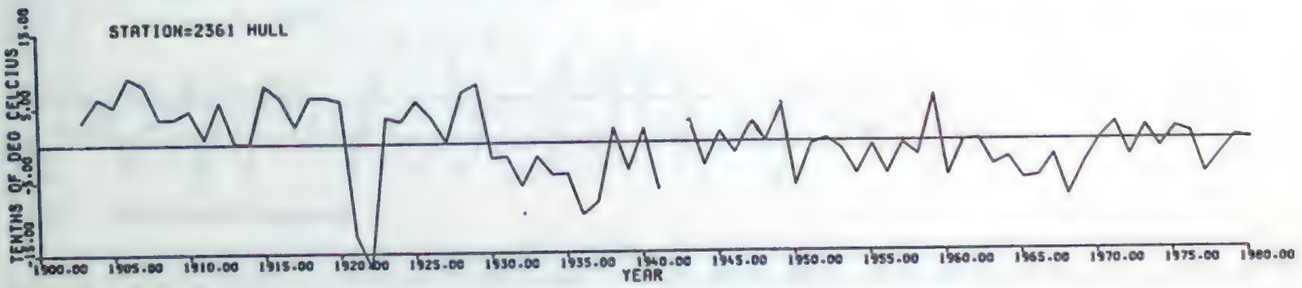


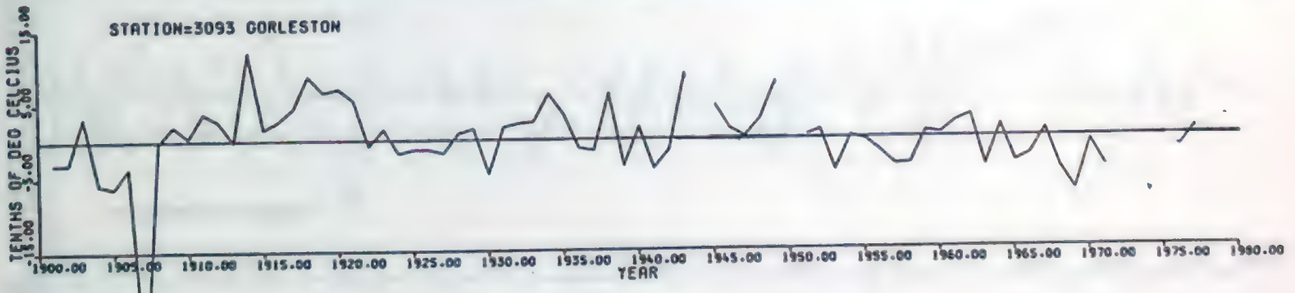


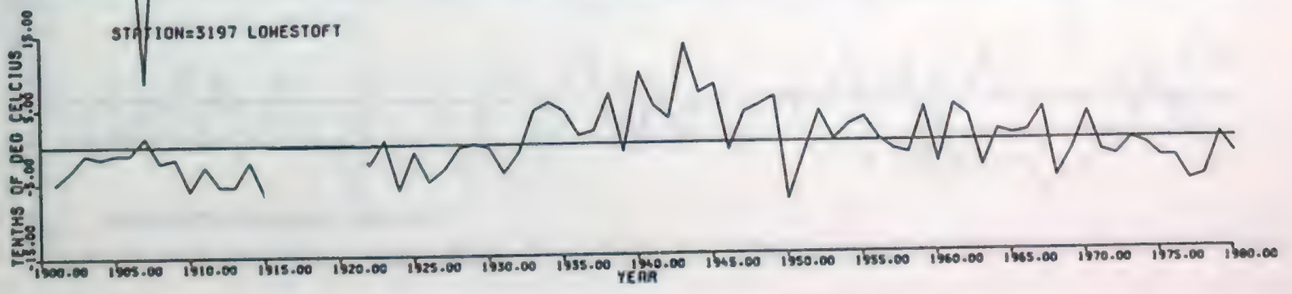


RESIDUALS (TEMP-MEAN) FOR MAX-MIN TEMPERATURE

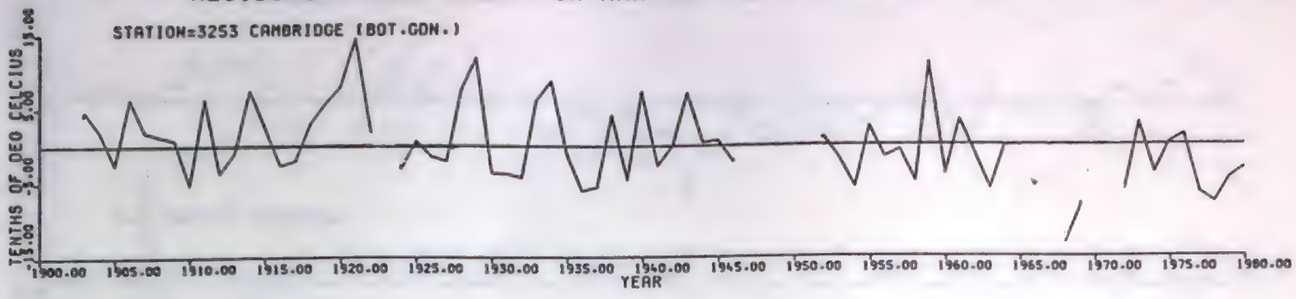


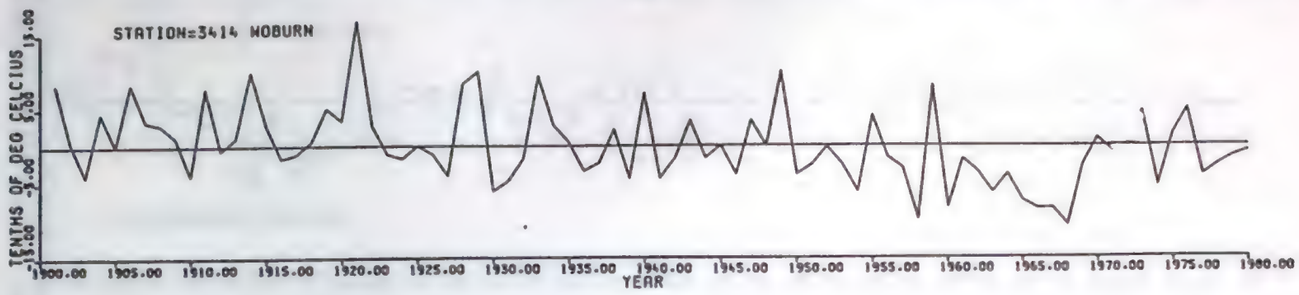


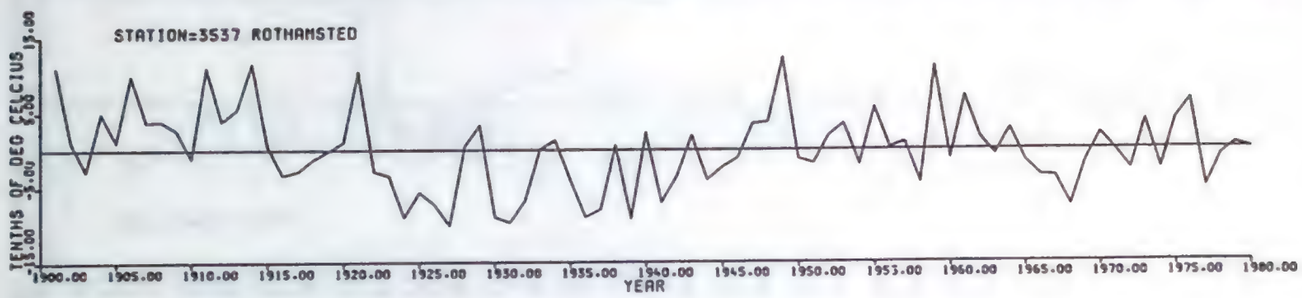


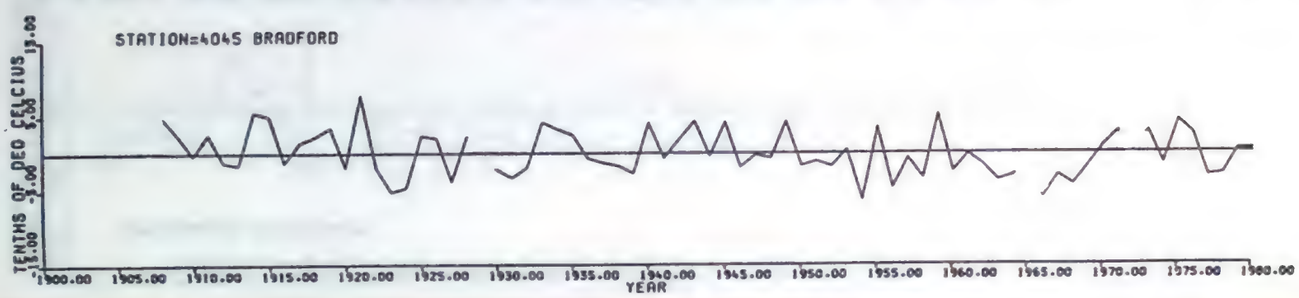


RESIDUALS (TEMP-MEAN) FOR MAX-MIN TEMPERATURE

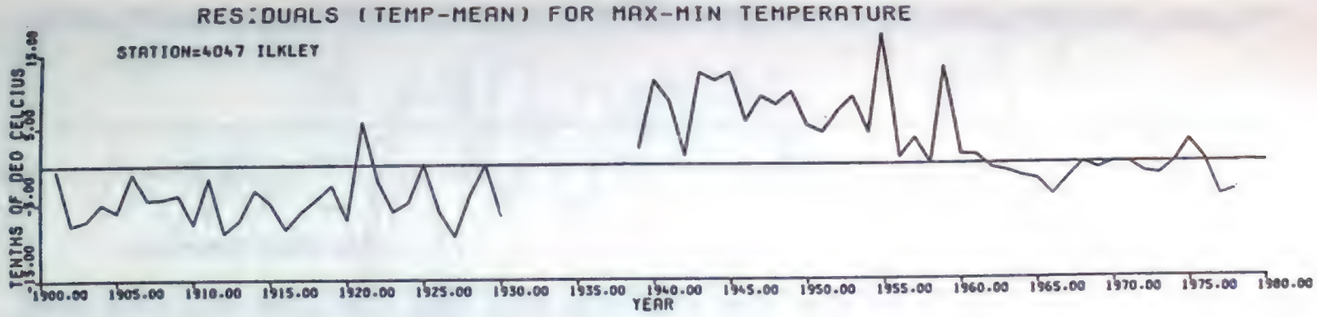


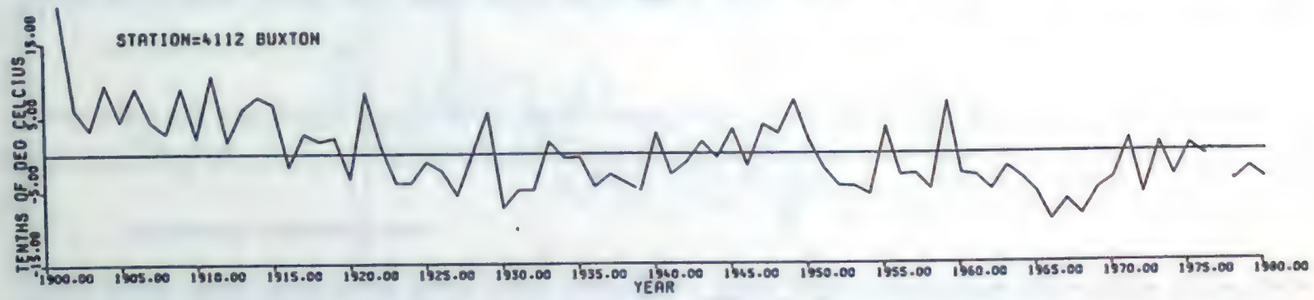


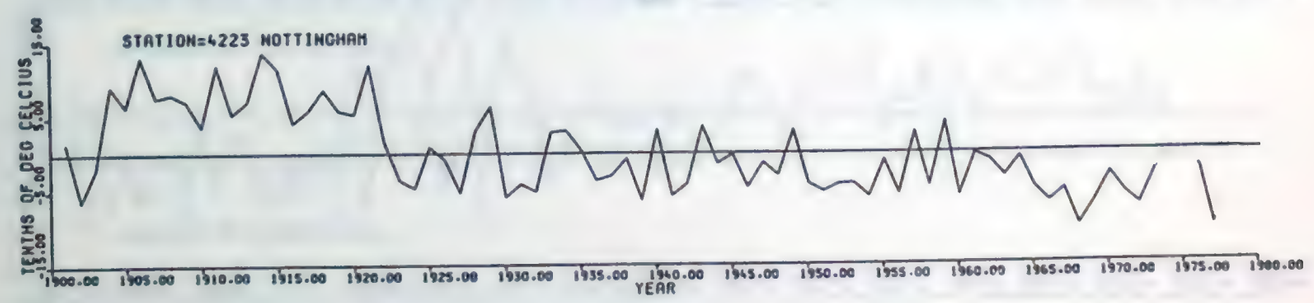


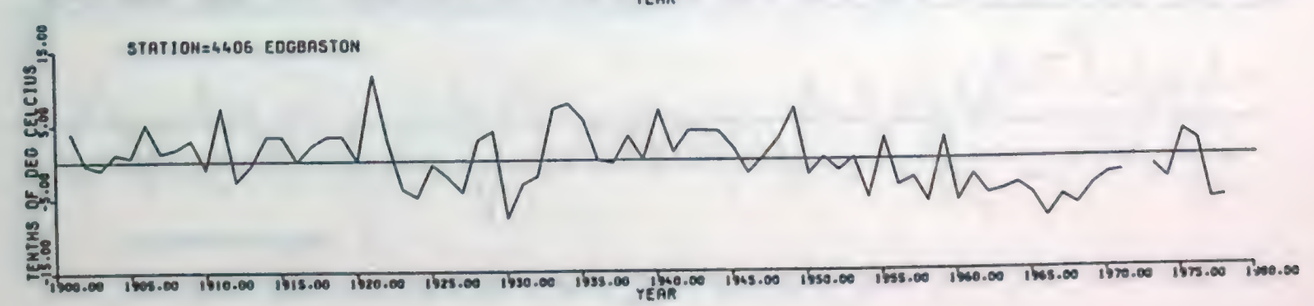


RESIDUALS (TEMP-MEAN) FOR MAX-MIN TEMPERATURE

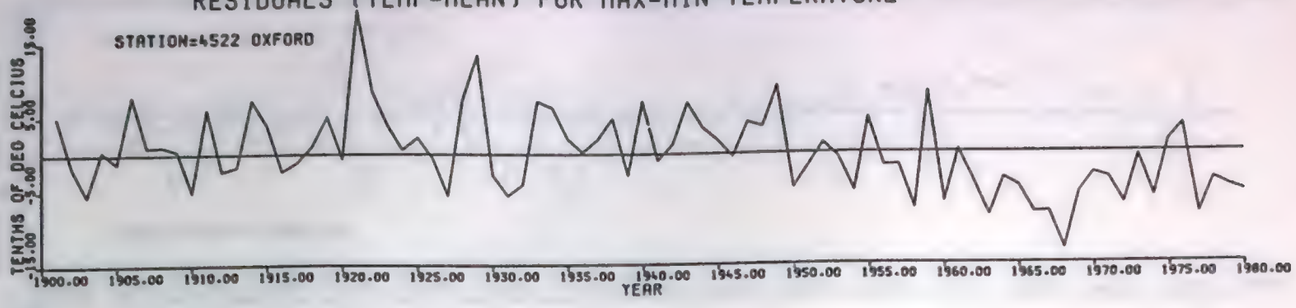


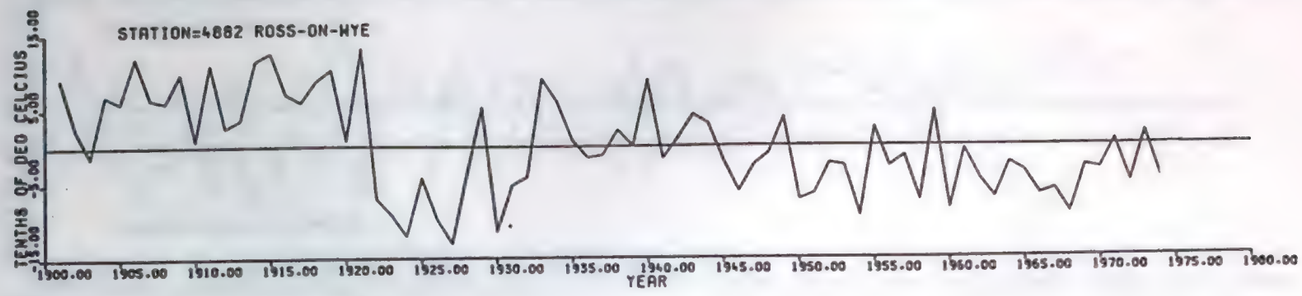


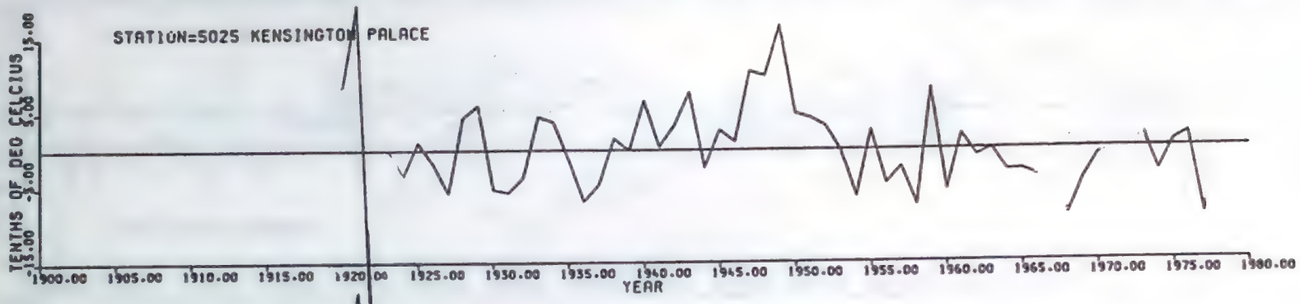


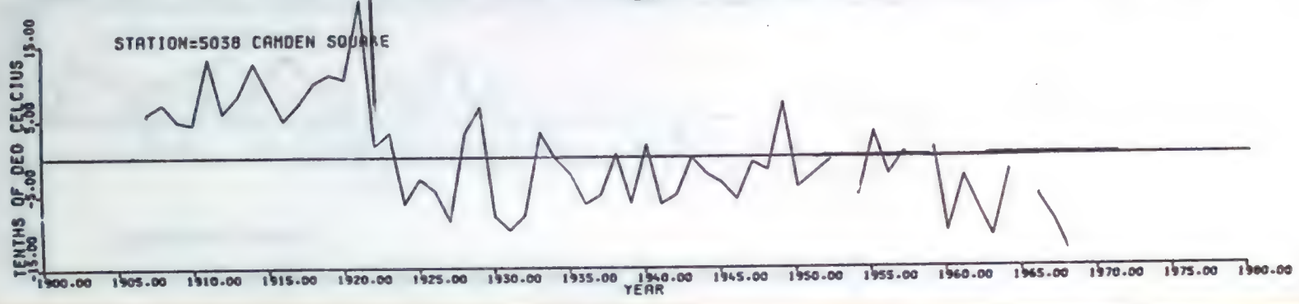


RESIDUALS (TEMP-MEAN) FOR MAX-MIN TEMPERATURE

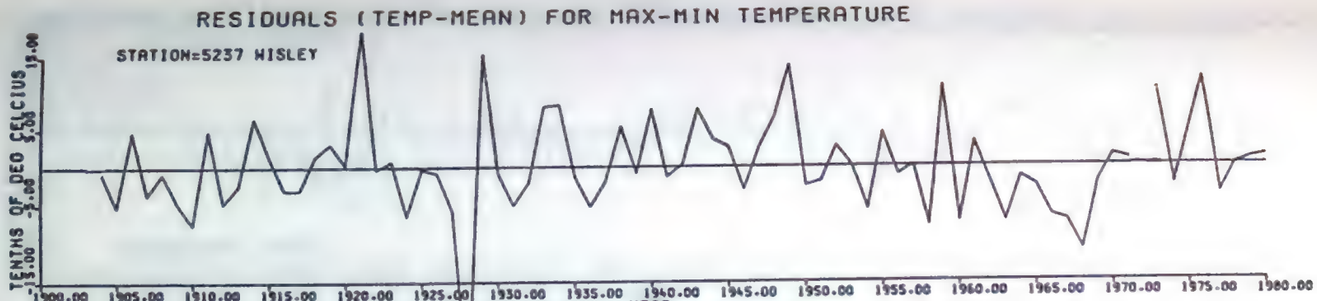


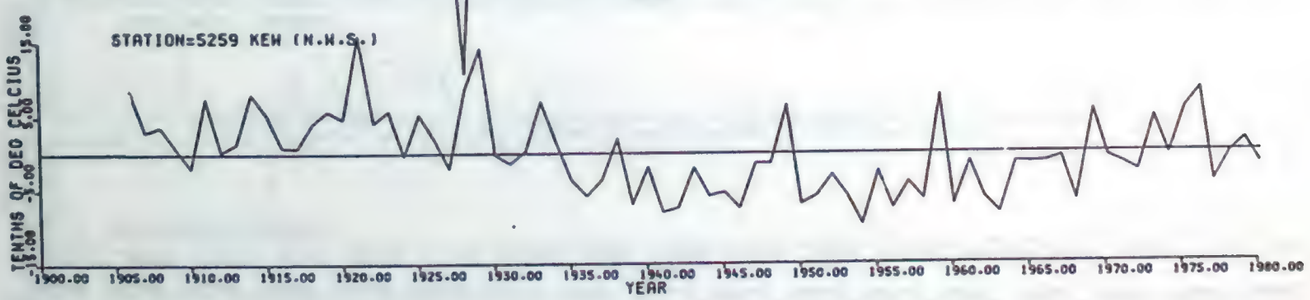


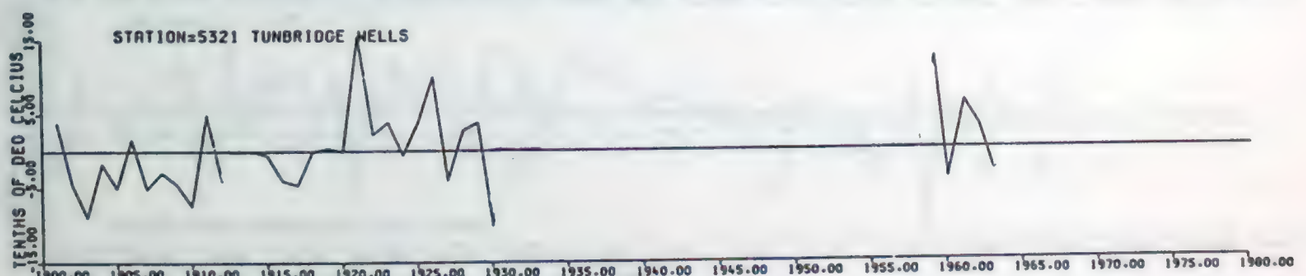


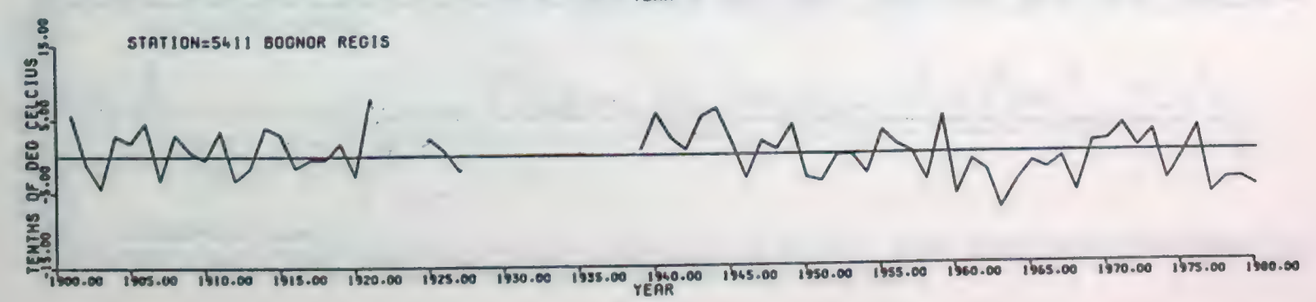


RESIDUALS (TEMP-MEAN) FOR MAX-MIN TEMPERATURE

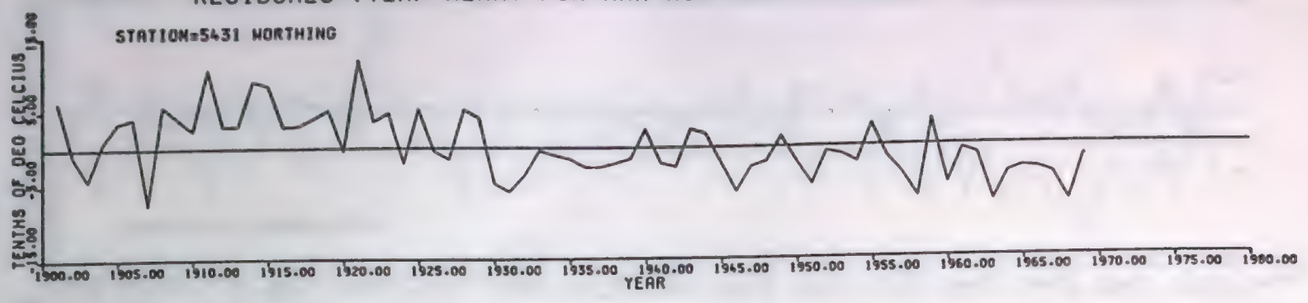


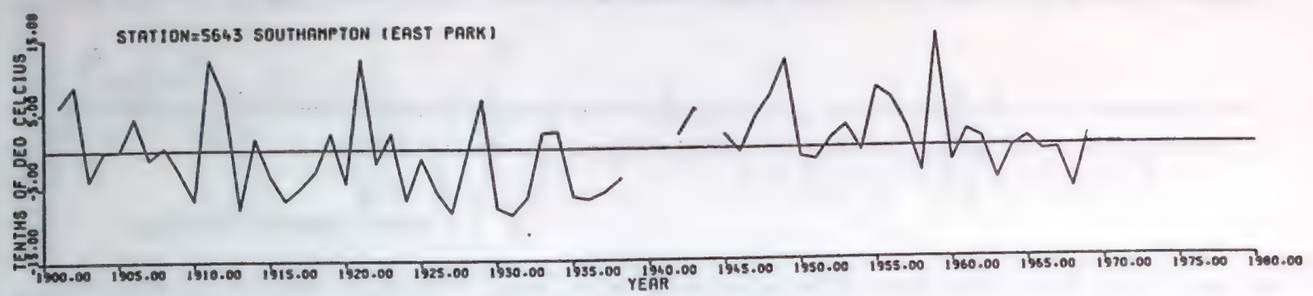


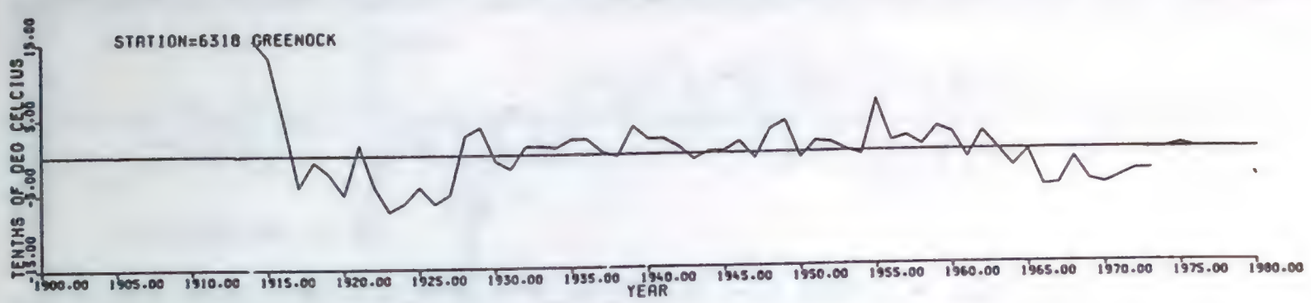


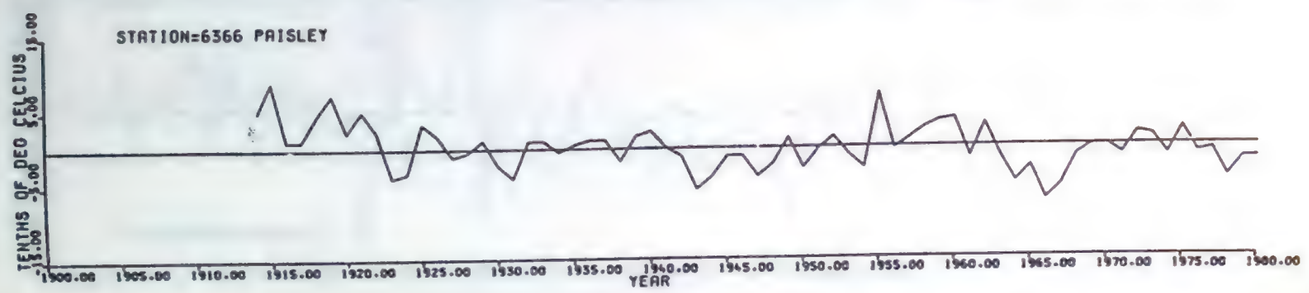


RESIDUALS (TEMP-MEAN) FOR MAX-MIN TEMPERATURE

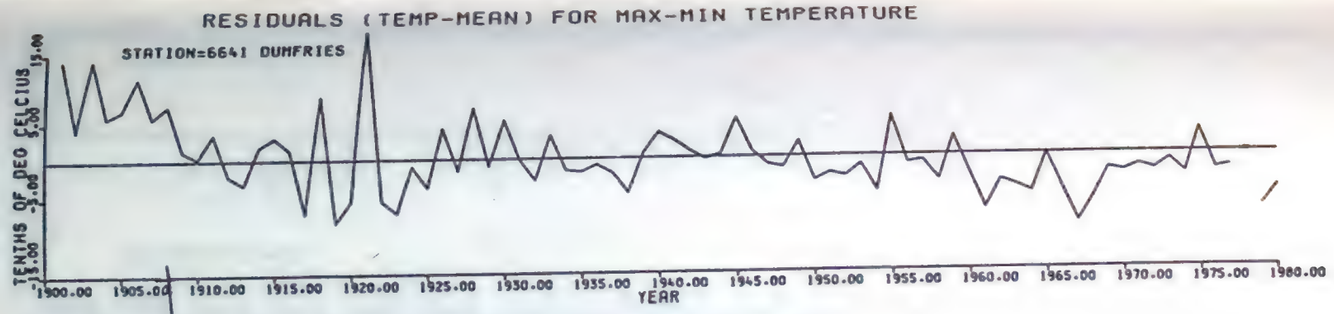


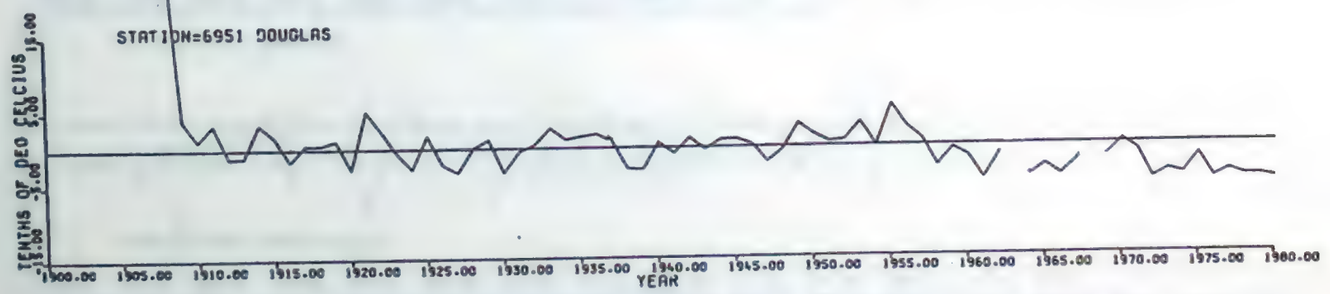


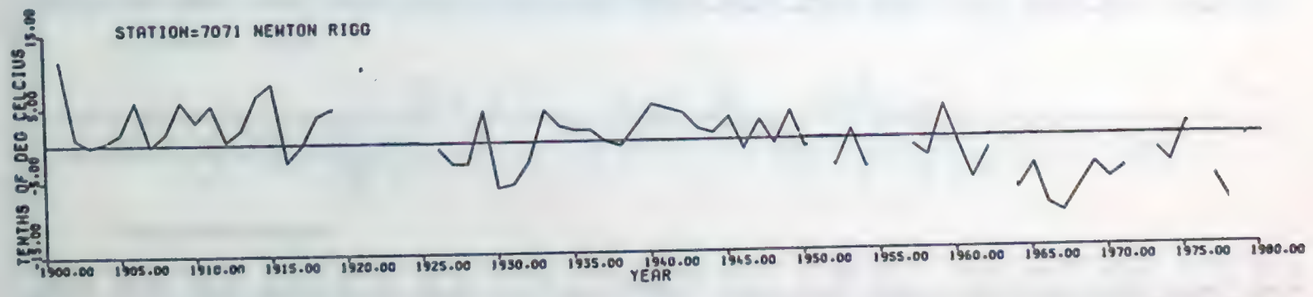


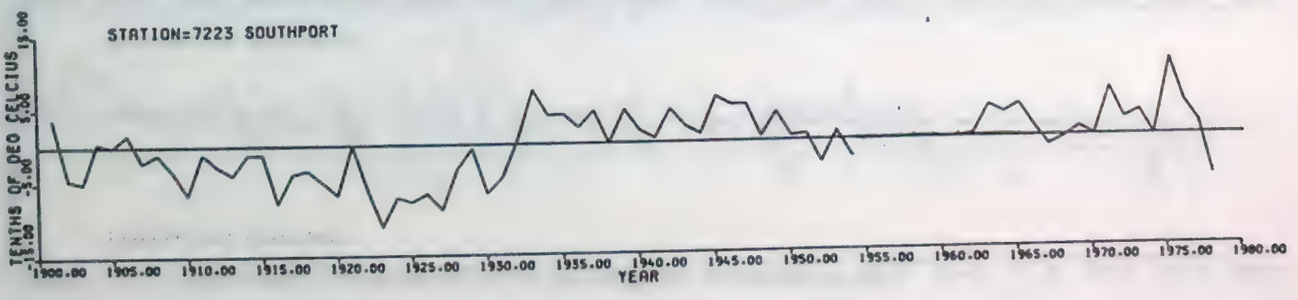


RESIDUALS (TEMP-MEAN) FOR MAX-MIN TEMPERATURE

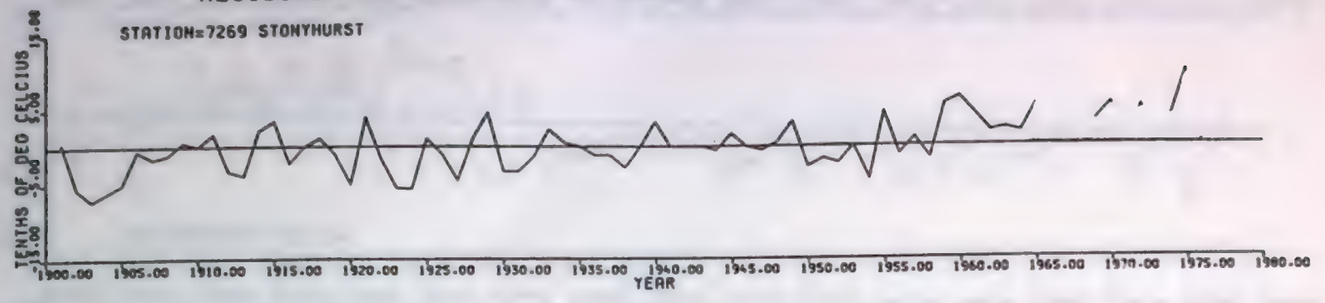


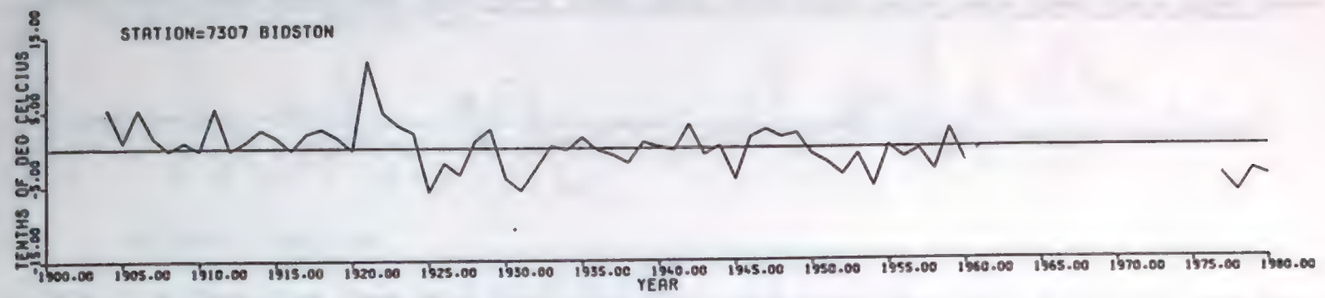


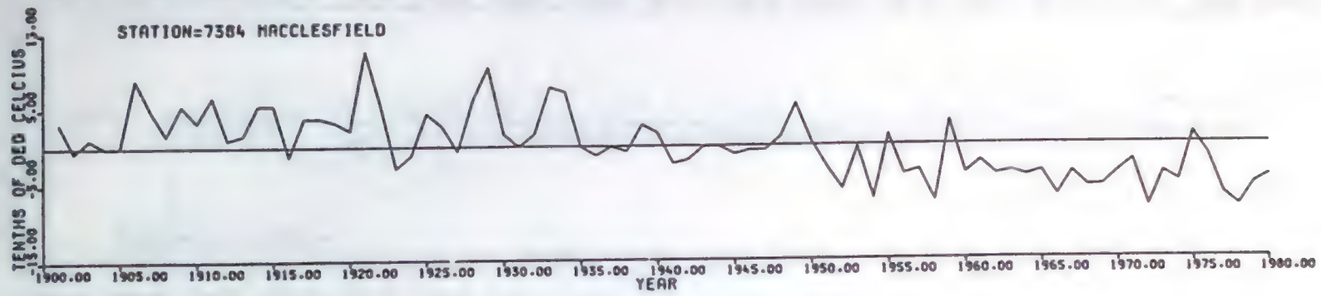


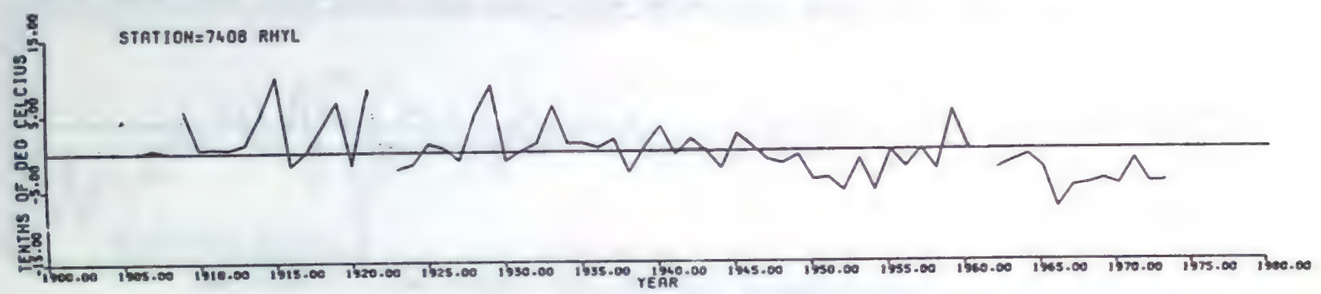


RESIDUALS (TEMP-MEAN) FOR MAX-MIN TEMPERATURE

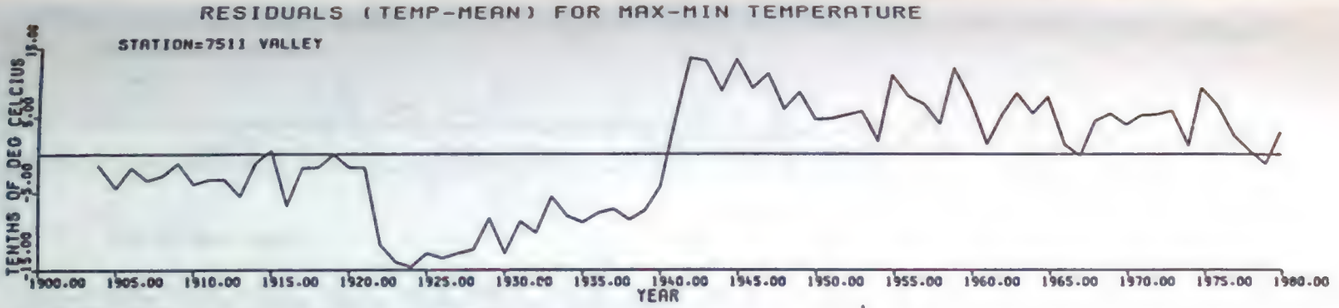


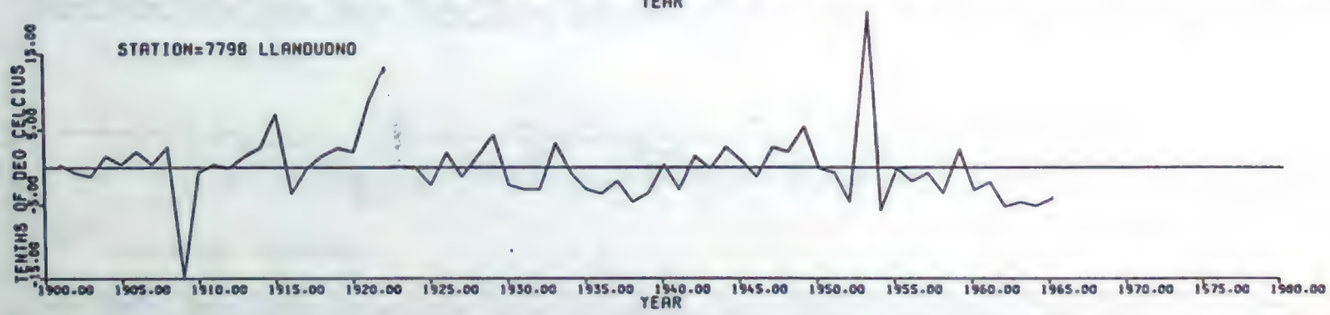


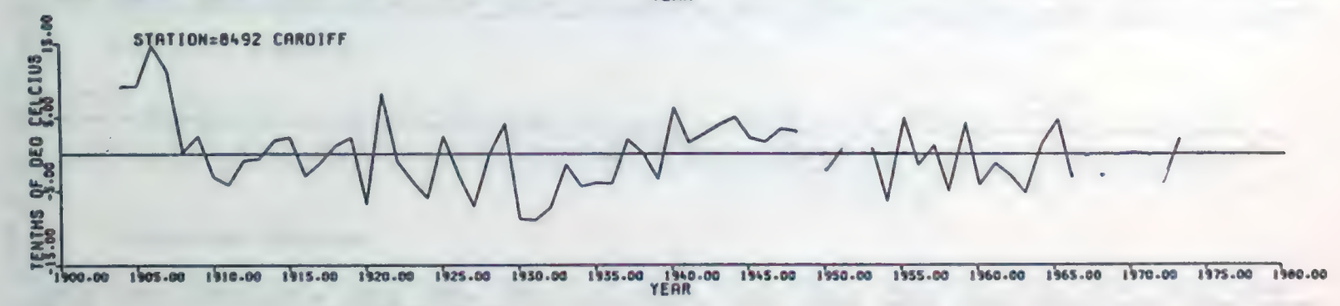


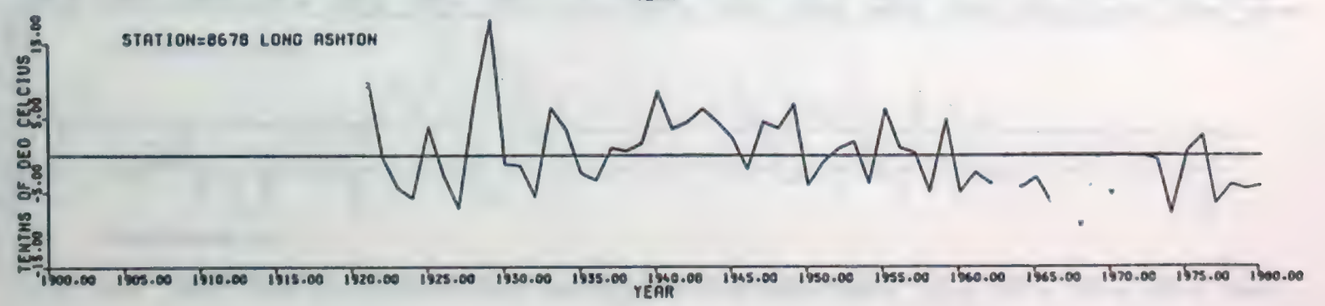


RESIDUALS (TEMP-MEAN) FOR MAX-MIN TEMPERATURE

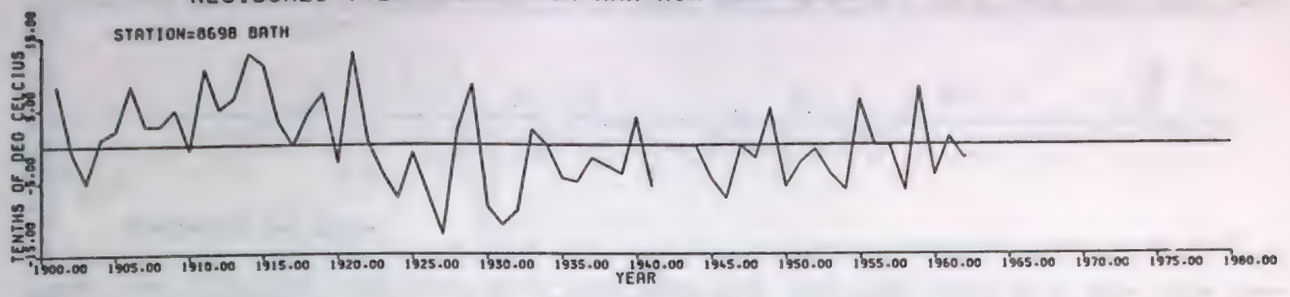


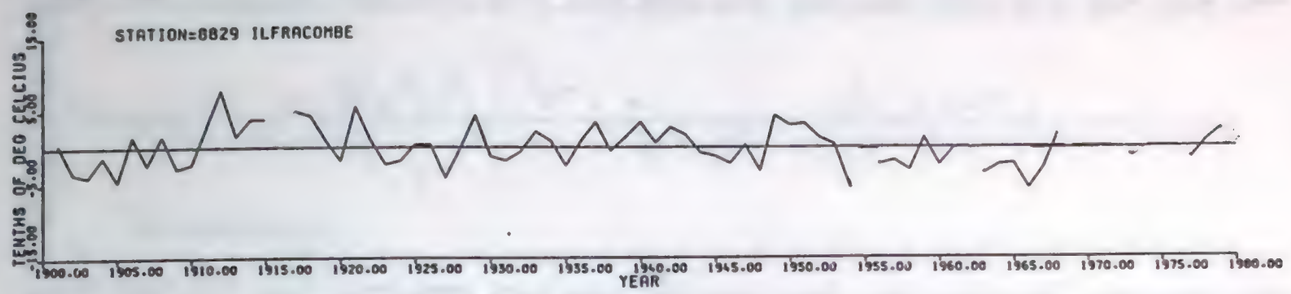


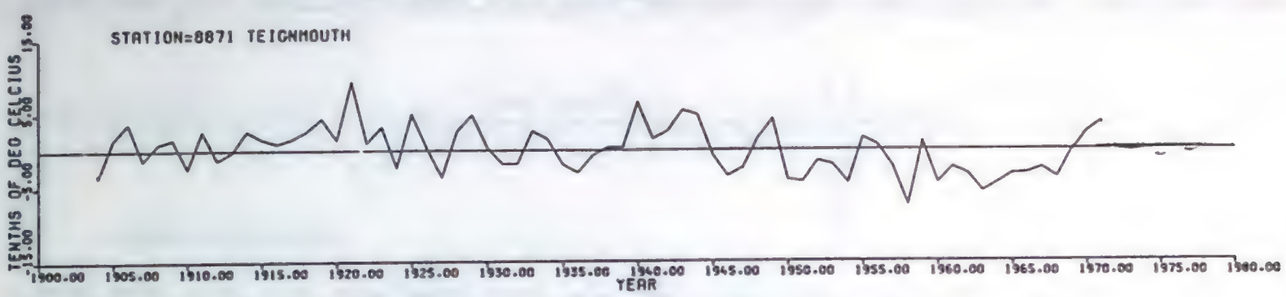


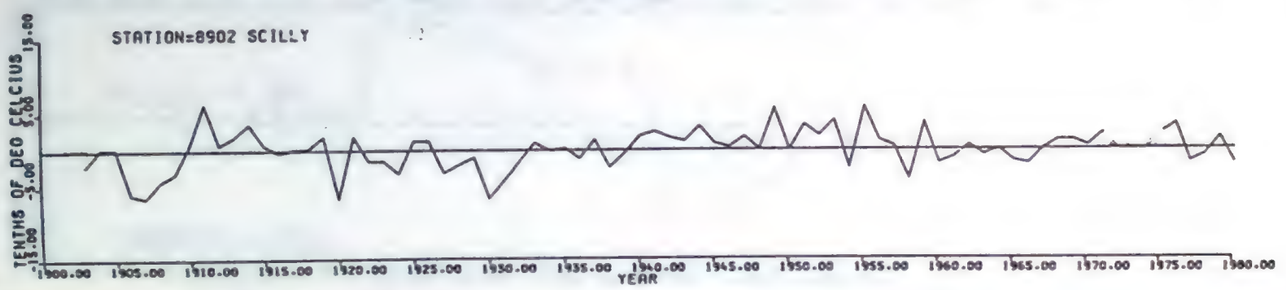


RESIDUALS (TEMP-MEAN) FOR MAX-MIN TEMPERATURE

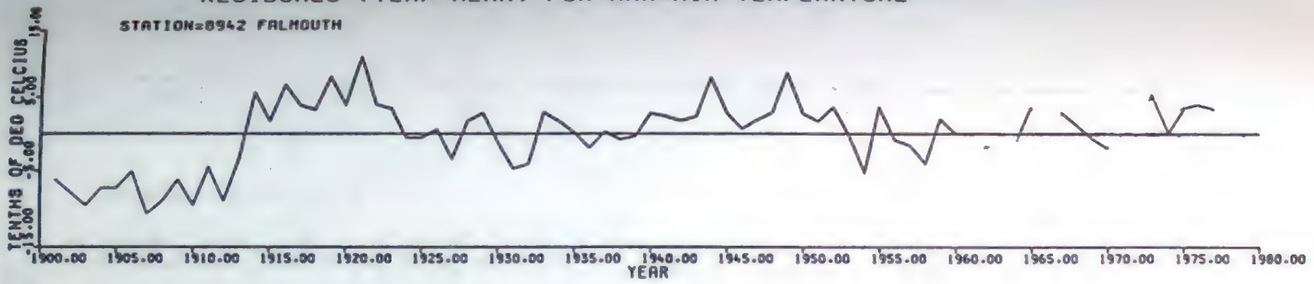


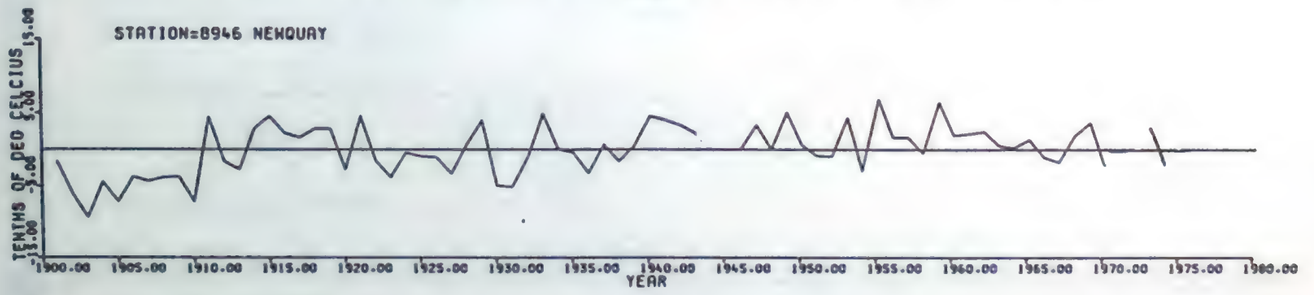


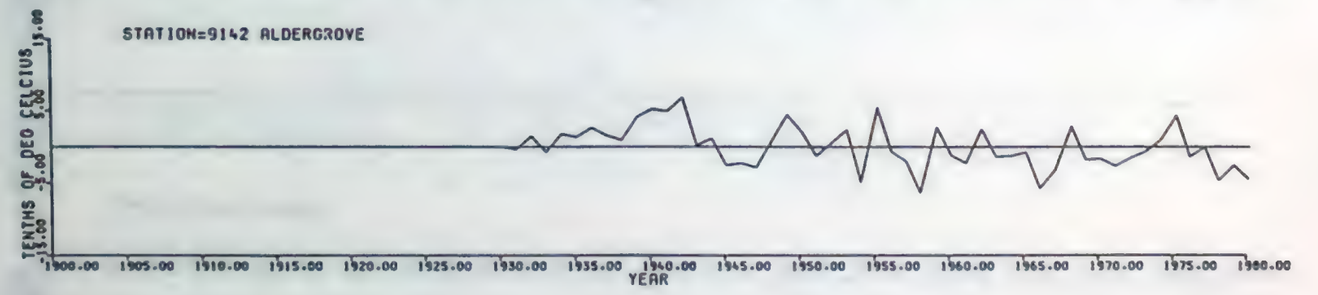


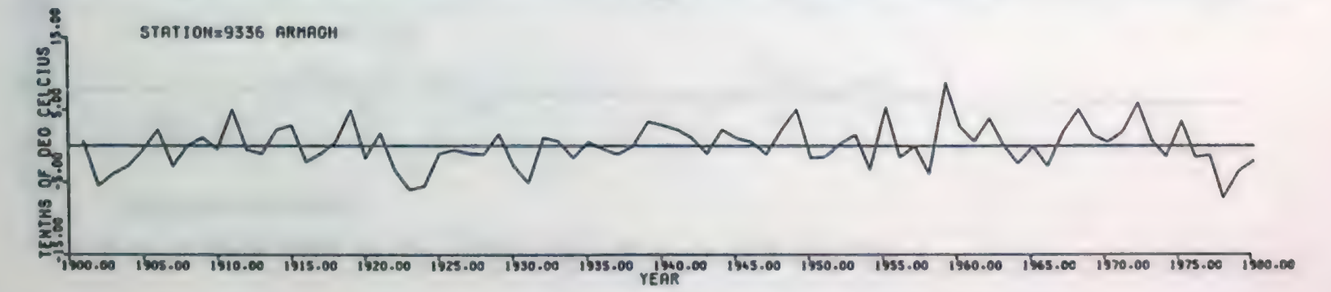


RESIDUALS (TEMP-MEAN) FOR MAX-MIN TEMPERATURE

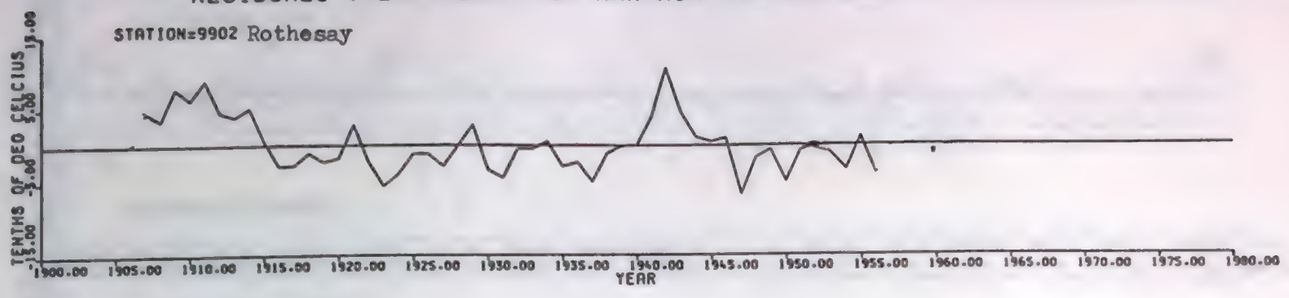


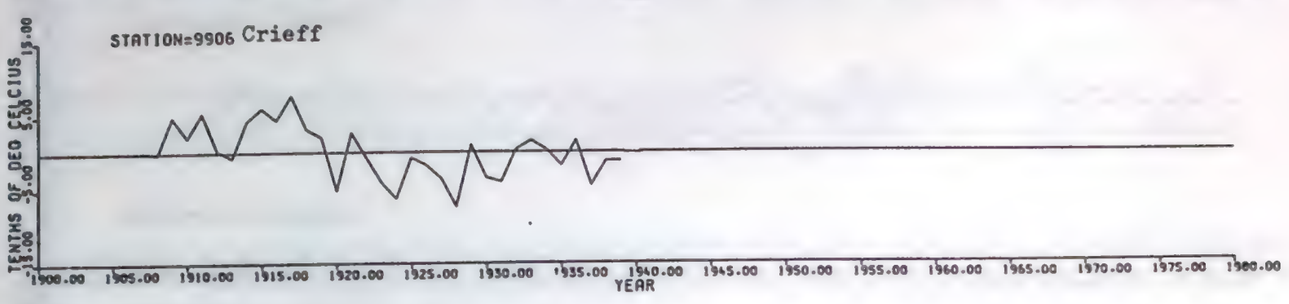


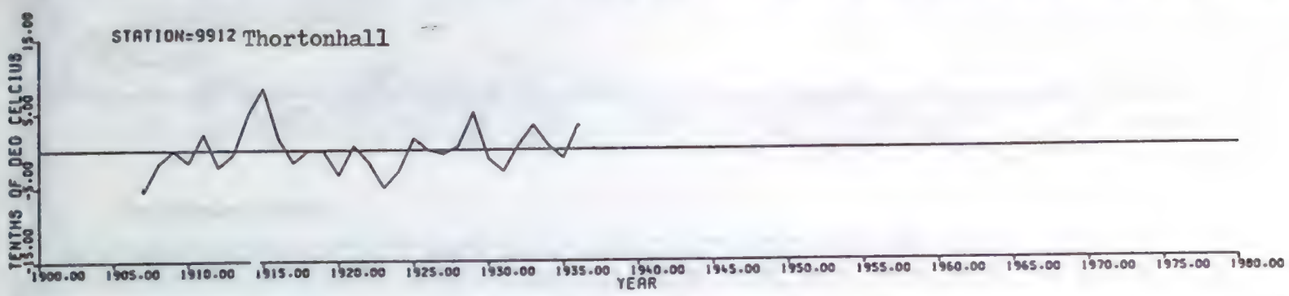


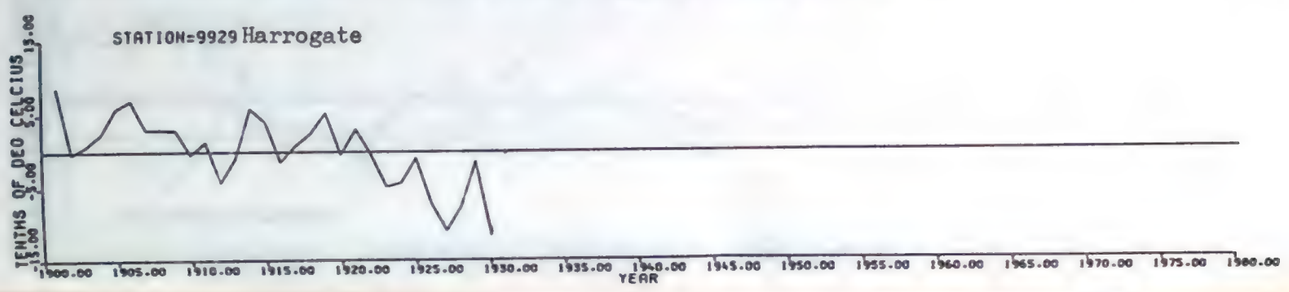


RESIDUALS (TEMP-MEAN) FOR MAX-MIN TEMPERATURE

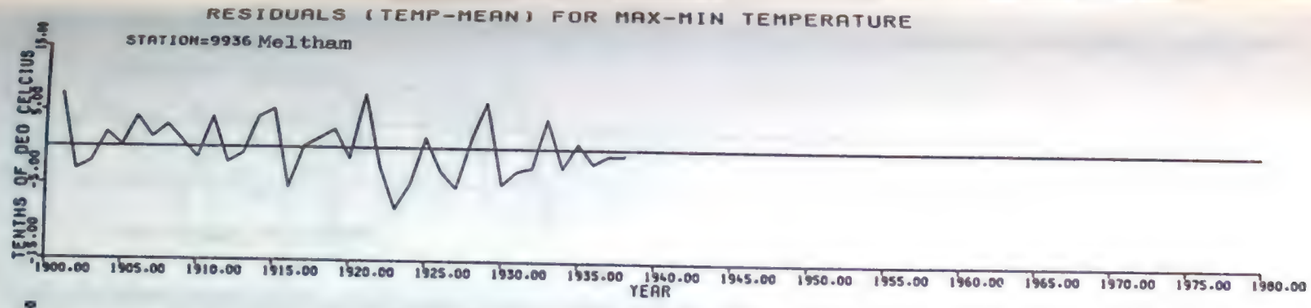


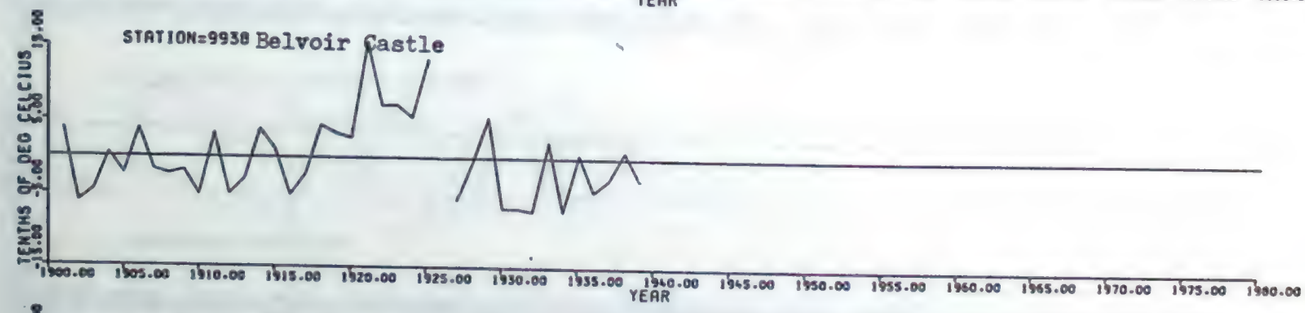


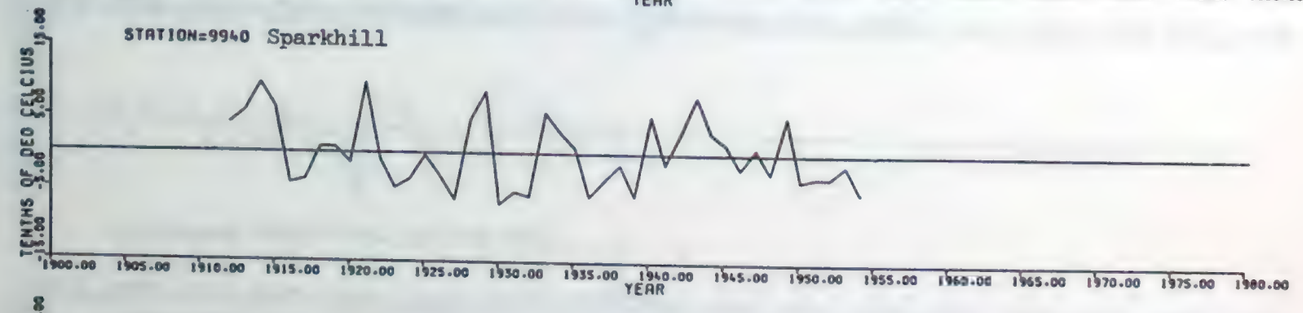


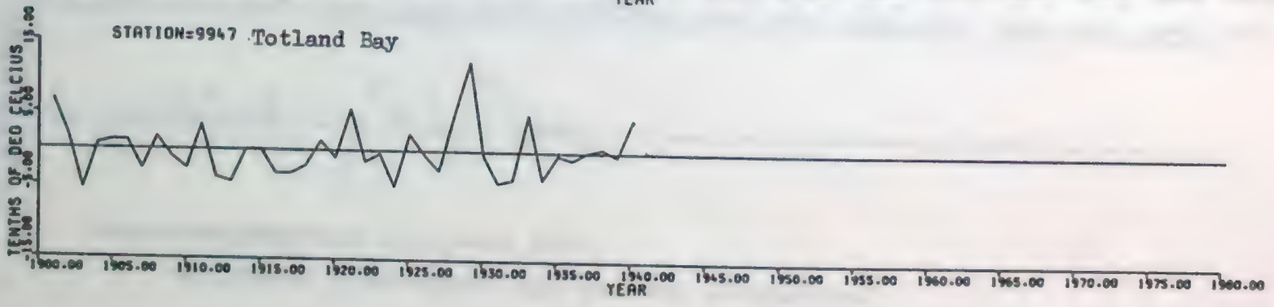


RESIDUALS (TEMP-MEAN) FOR MAX-MIN TEMPERATURE

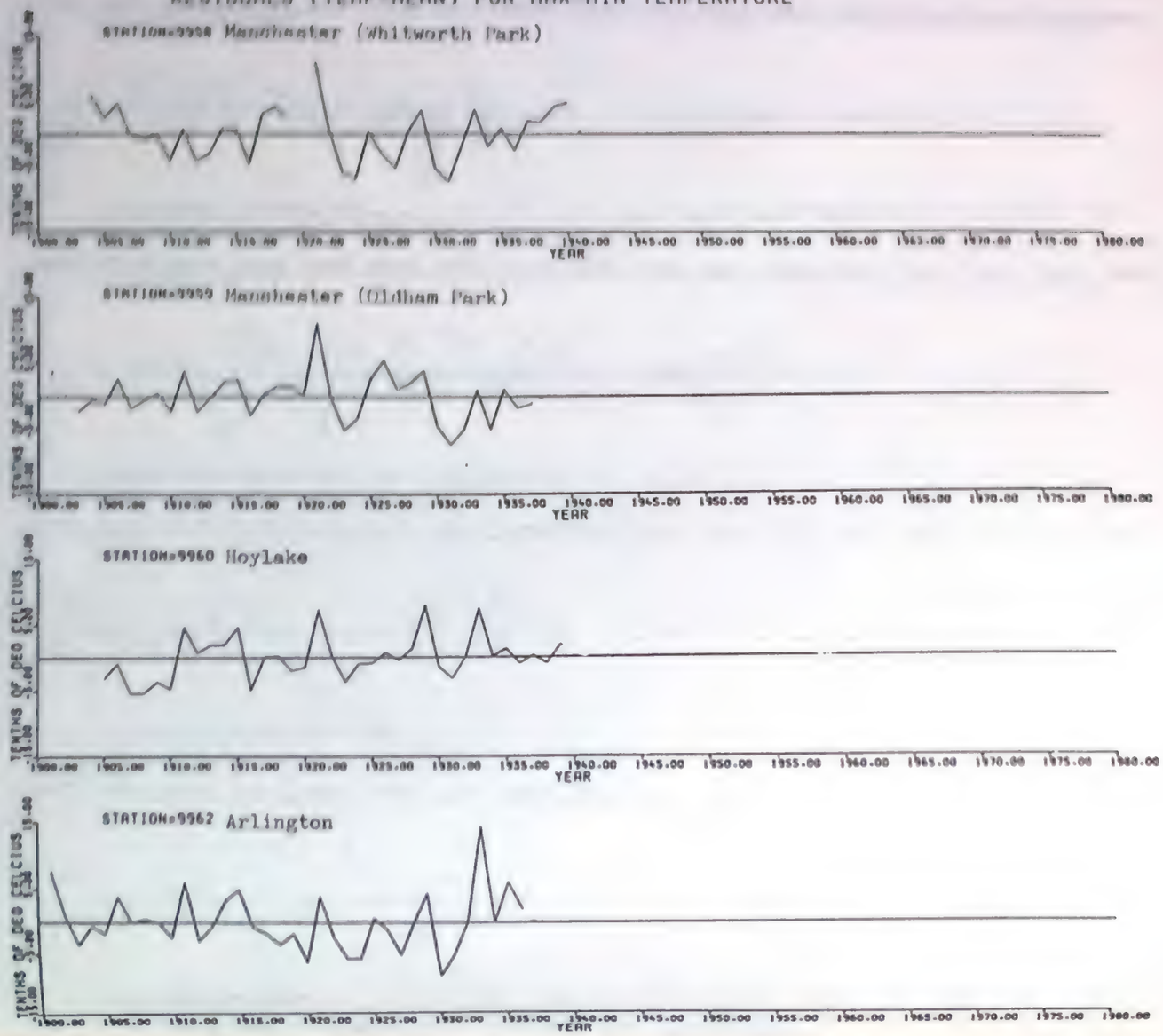








RESIDUALS (TEMP-MEAN) FOR MAX-MIN TEMPERATURE



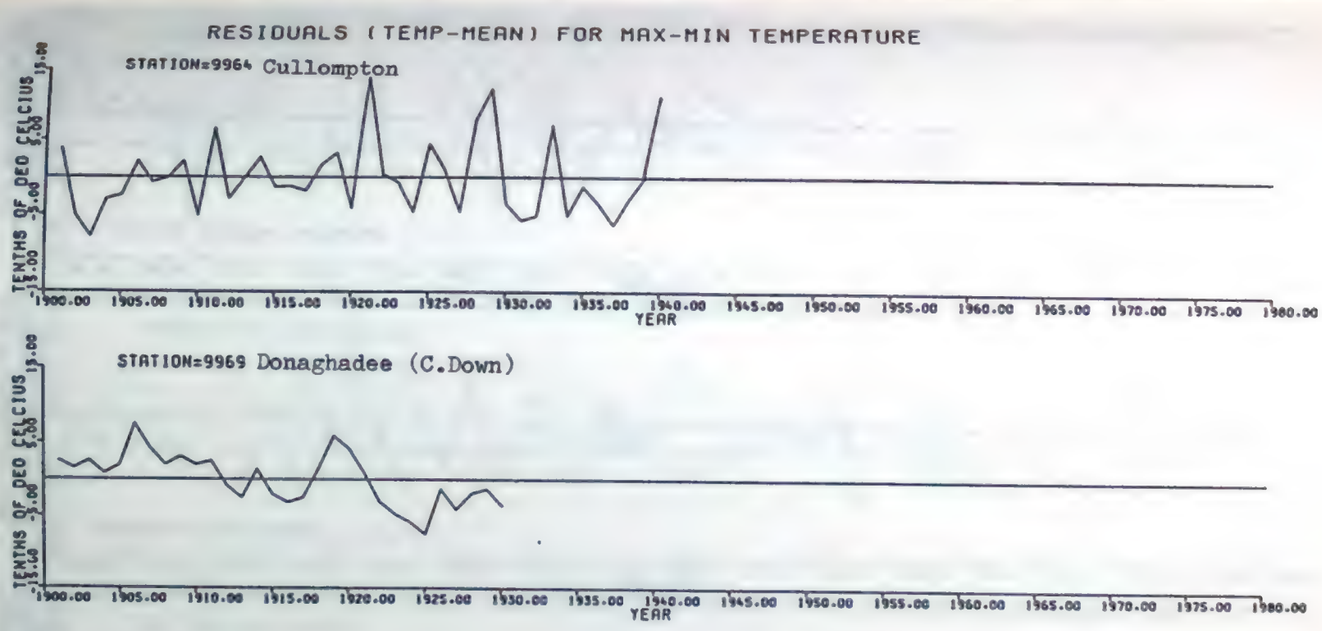
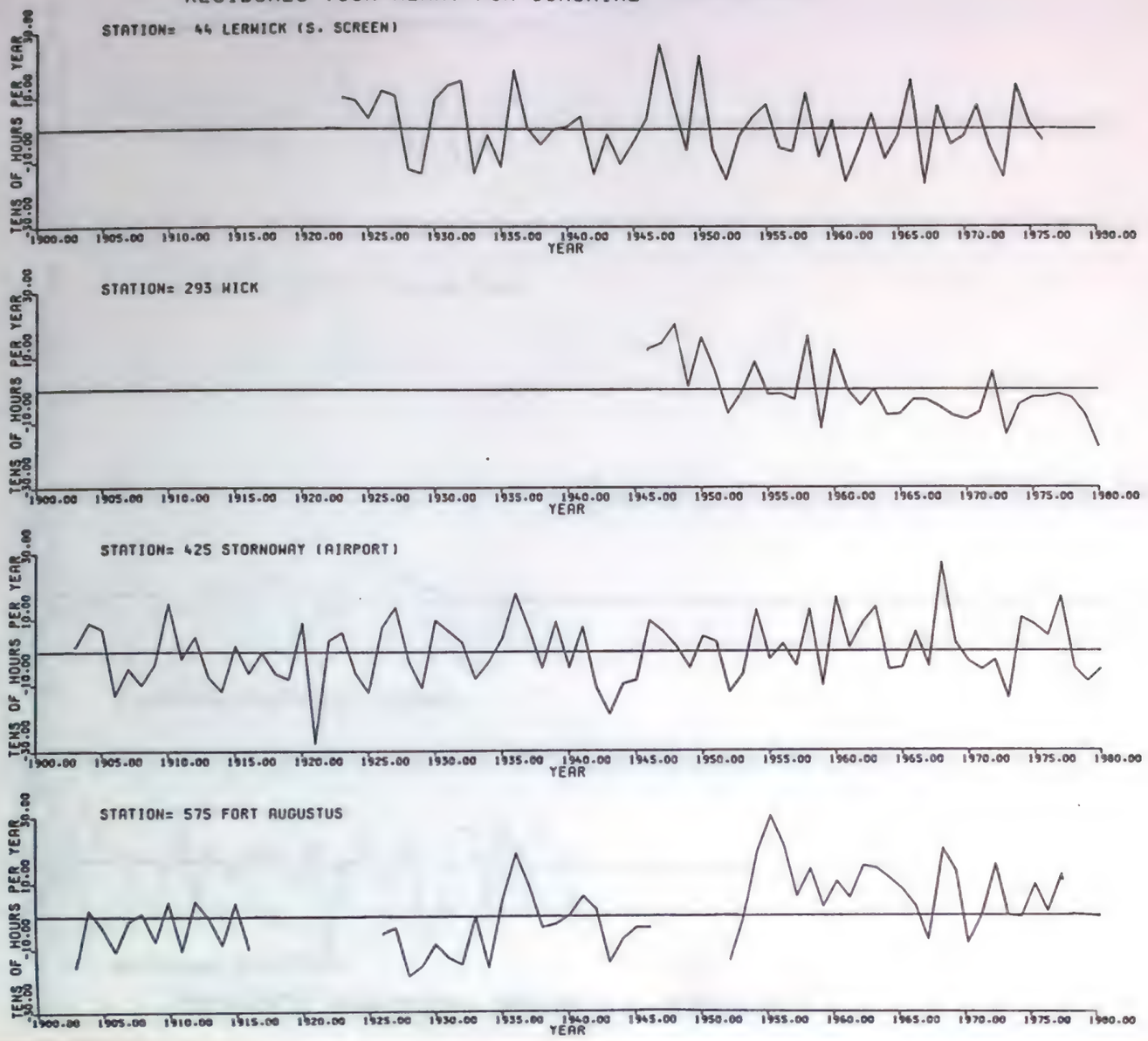
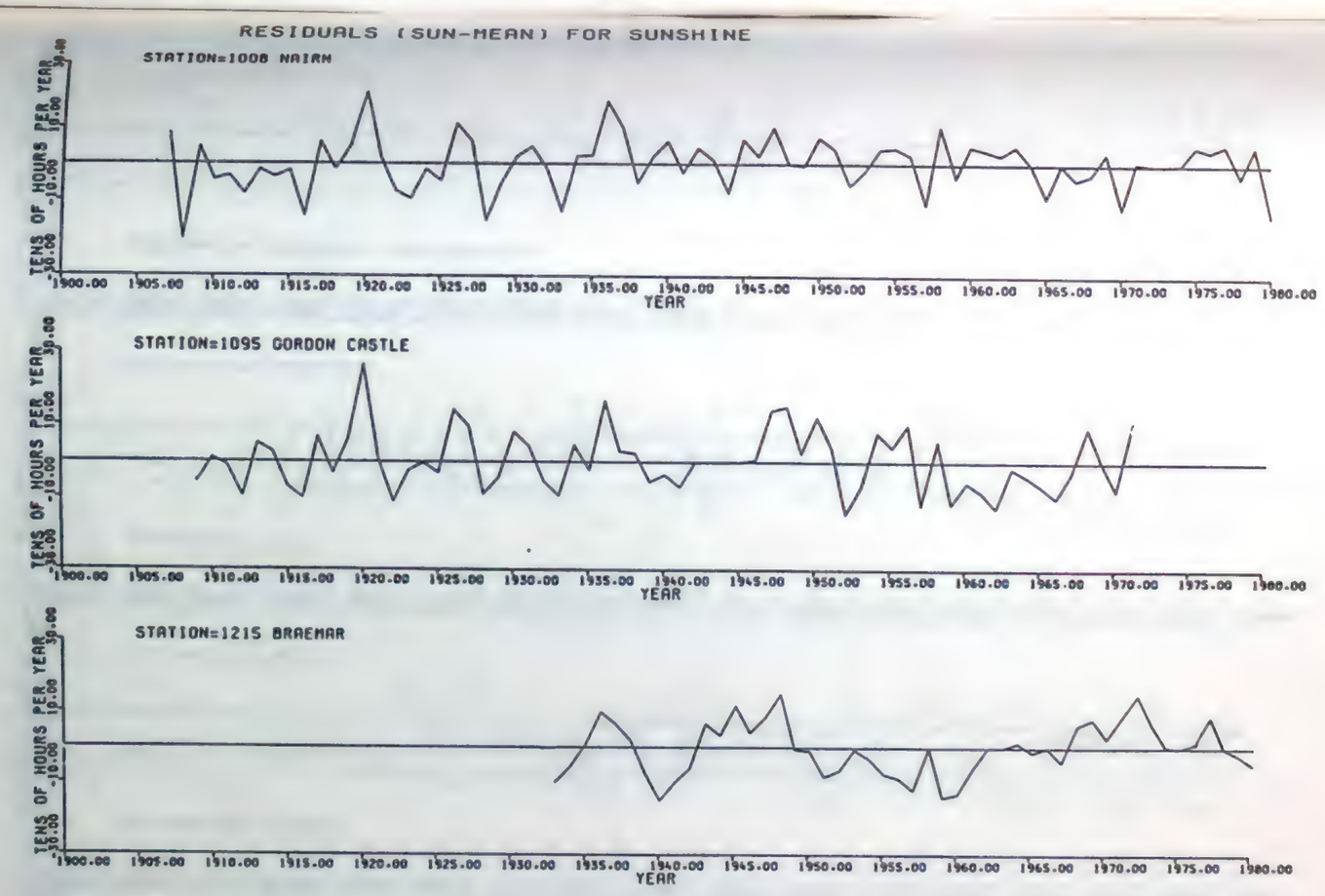


Figure 2

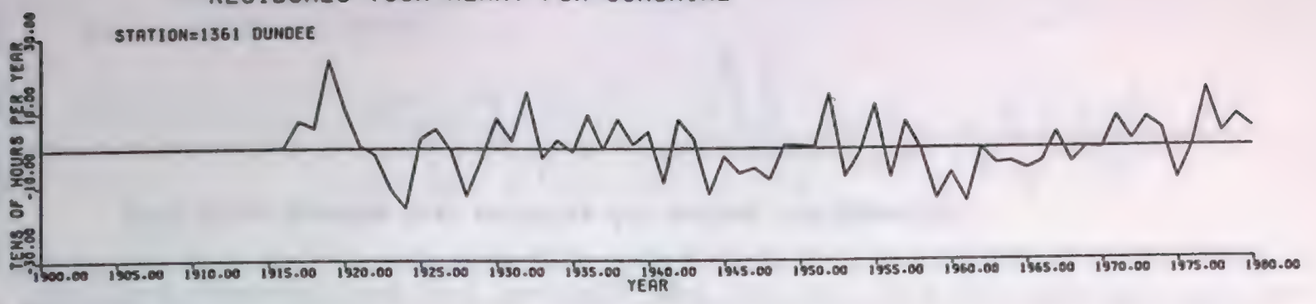




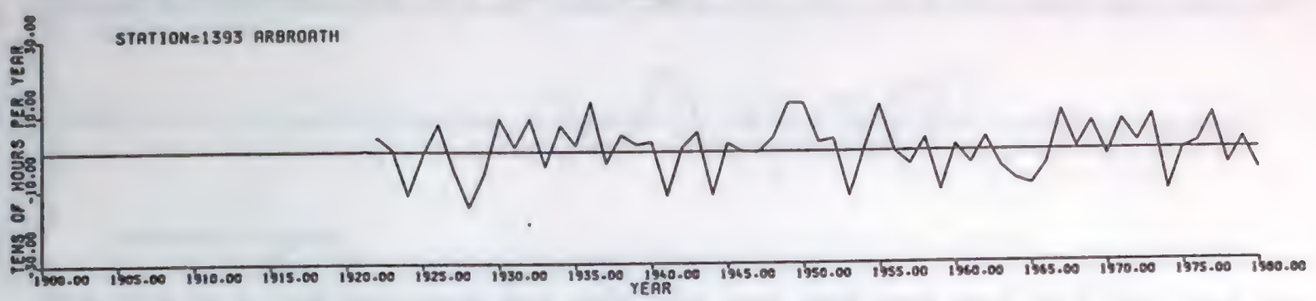
There is no sunshine data available for station 1226(Balmoral).

RESIDUALS (SUN-MEAN) FOR SUNSHINE

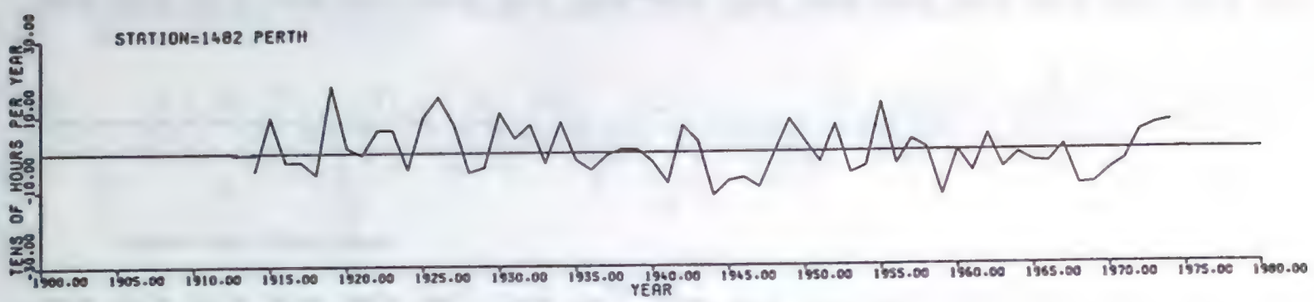
STATION=1361 DUNDEE



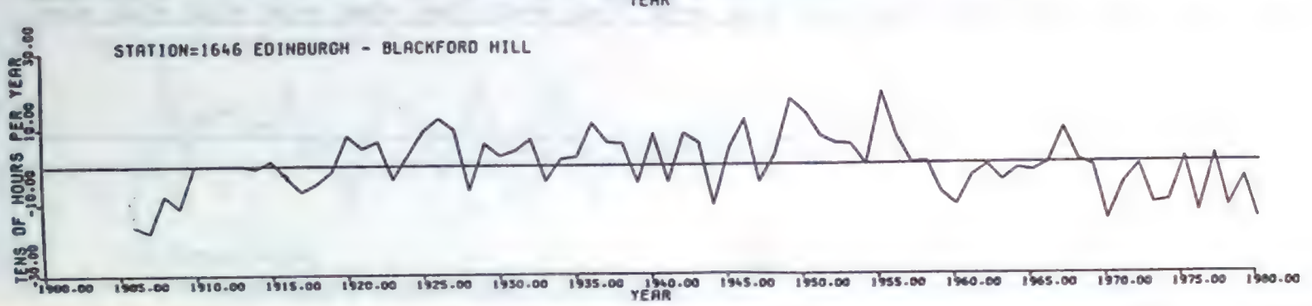
STATION=1393 ARBROATH



STATION=1482 PERTH

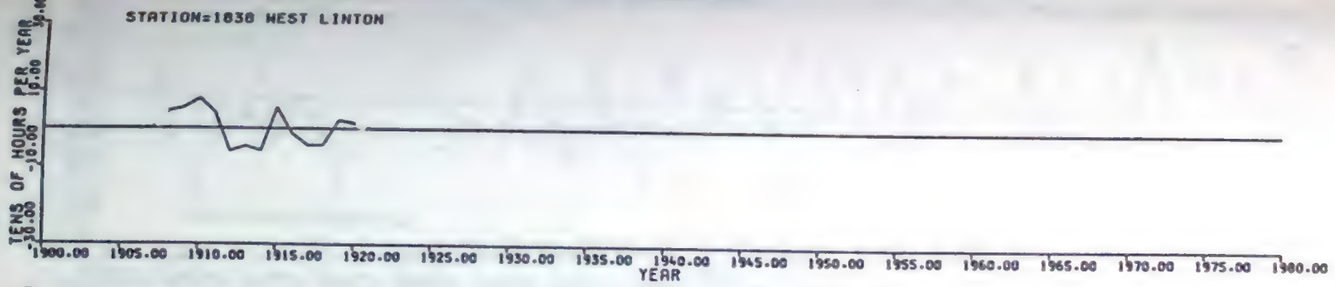


STATION=1646 EDINBURGH - BLACKFORD HILL

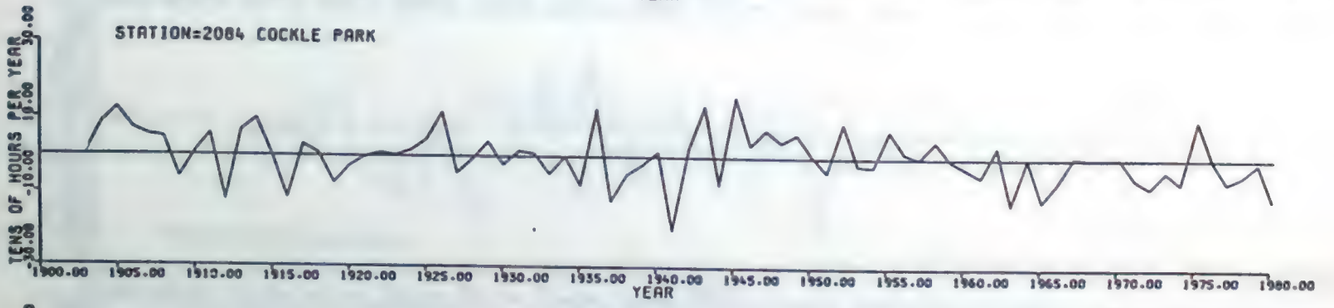


RESIDUALS (SUN-MEAN) FOR SUNSHINE

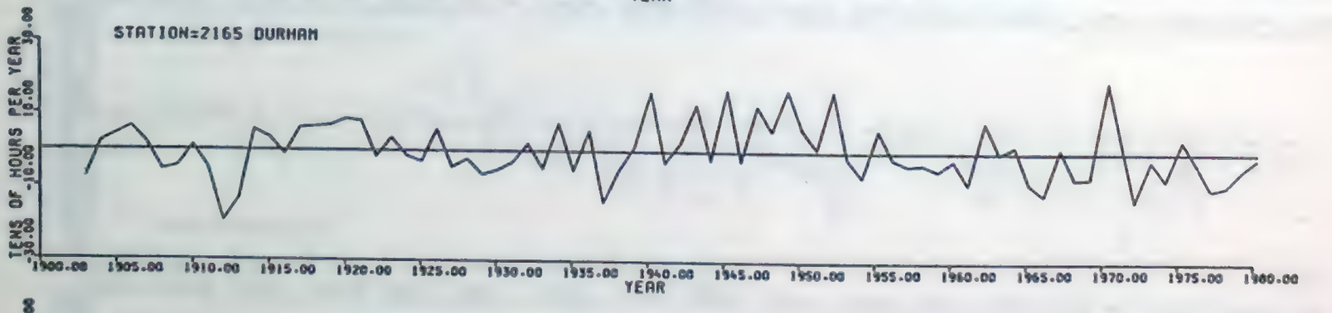
STATION=1838 WEST LINTON



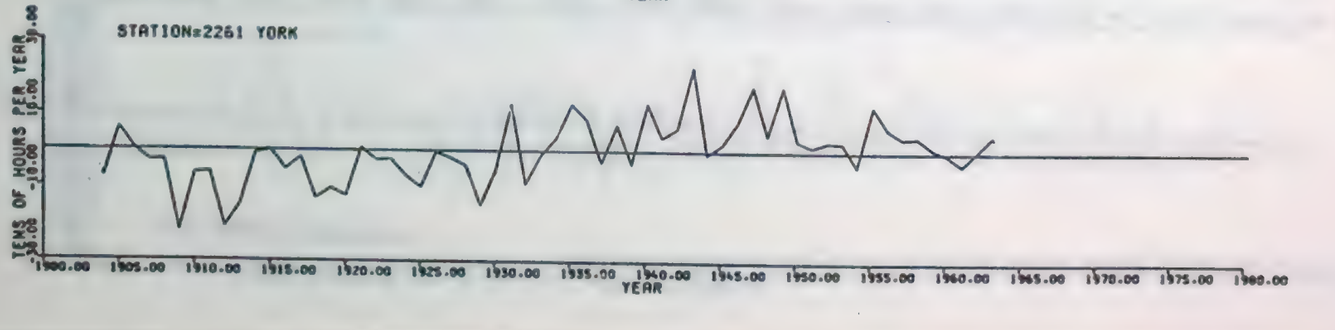
STATION=2084 COCKLE PARK



STATION=2165 DURHAM

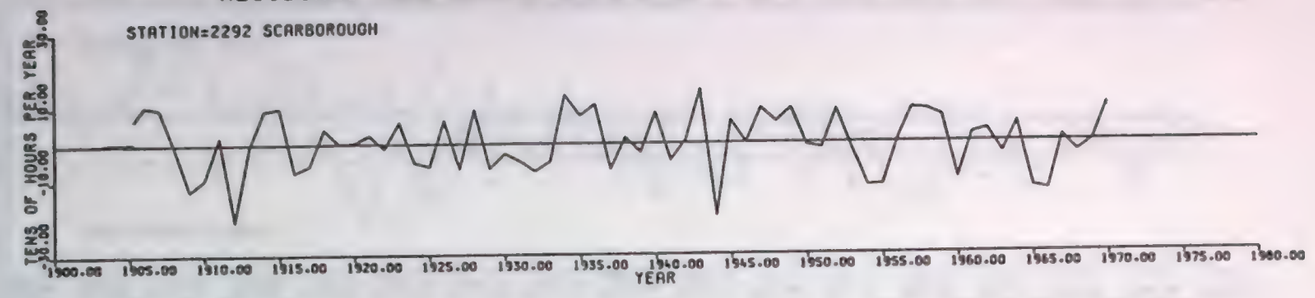


STATION=2261 YORK

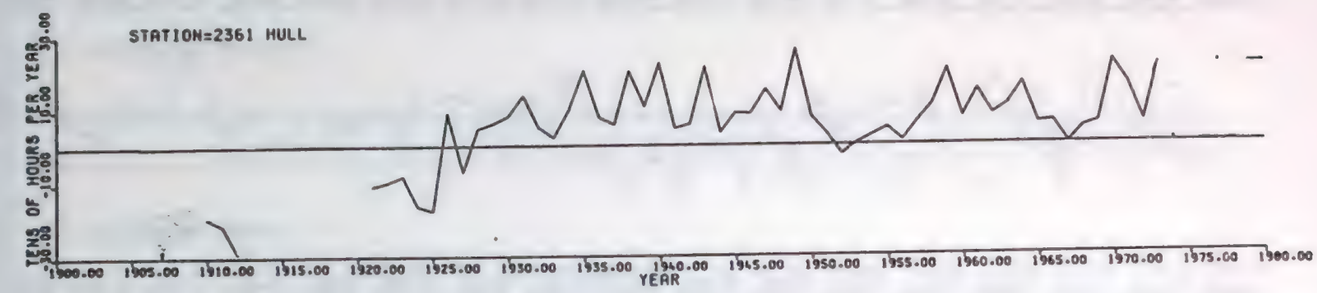


RESIDUALS (SUN-MEAN) FOR SUNSHINE

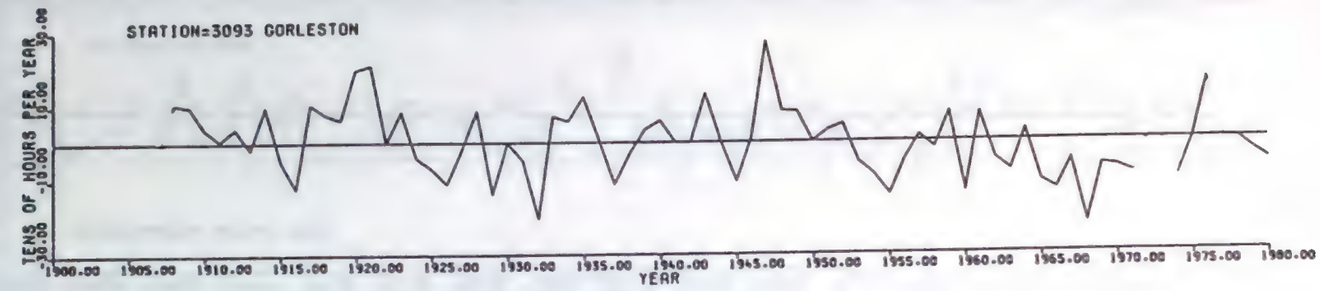
STATION=2292 SCARBOROUGH



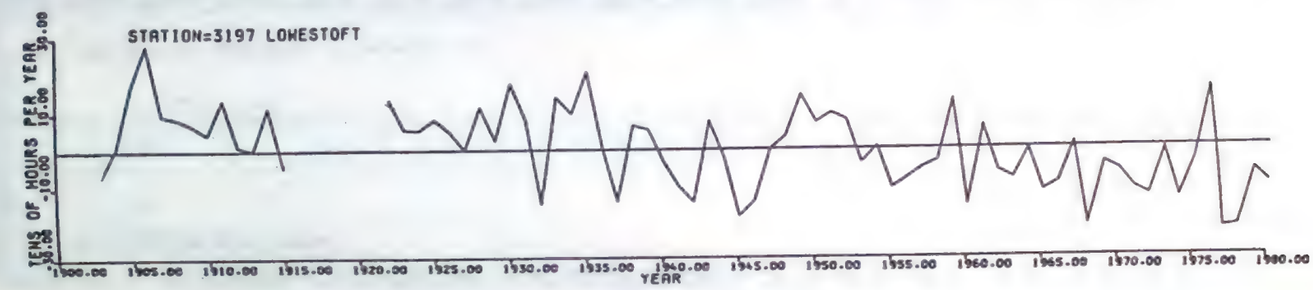
STATION=2361 HULL



STATION=3093 GORLESTON

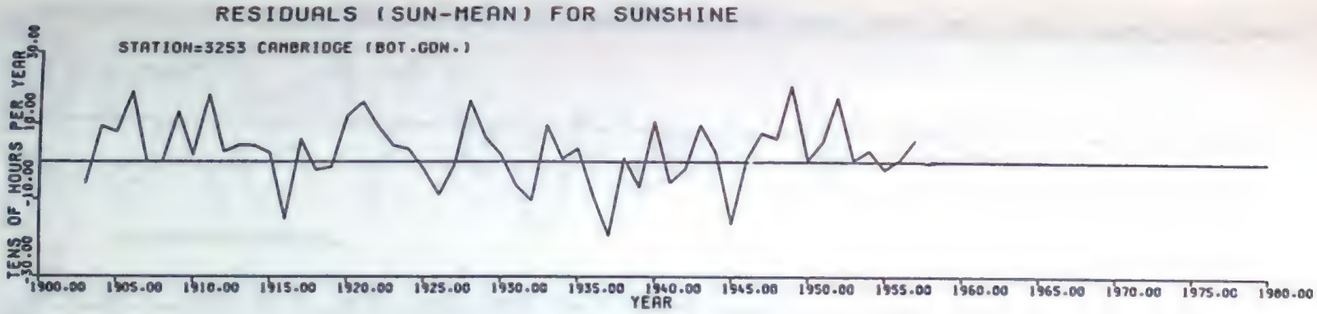


STATION=3197 LOWESTOFT

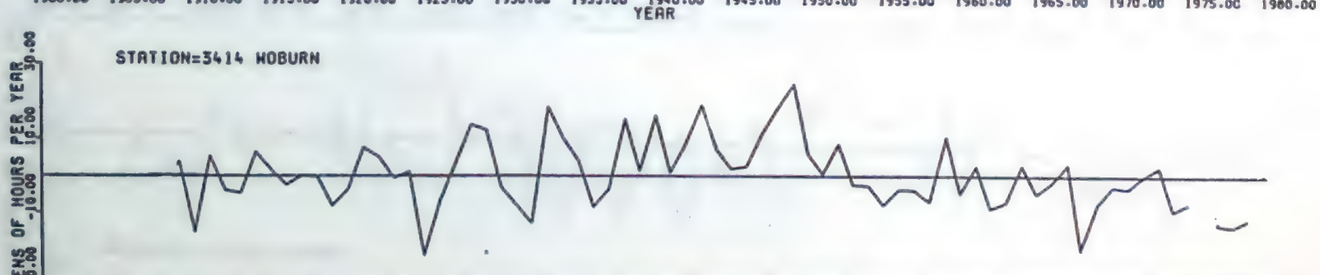


RESIDUALS (SUN-MEAN) FOR SUNSHINE

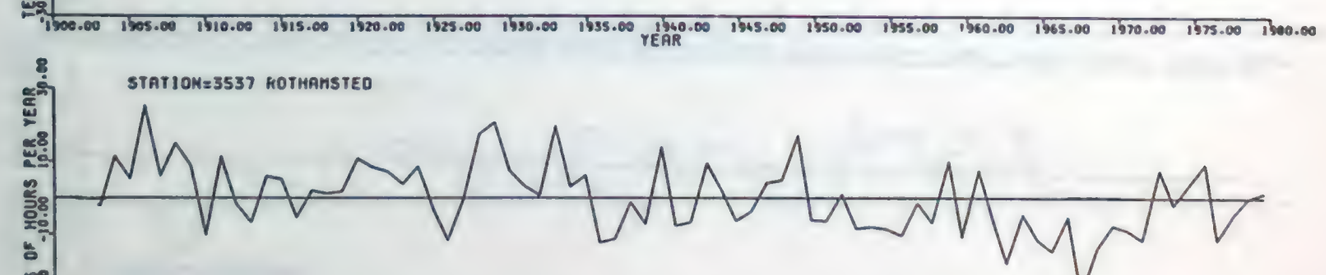
STATION=3253 CAMBRIDGE (BOT.GDN.)



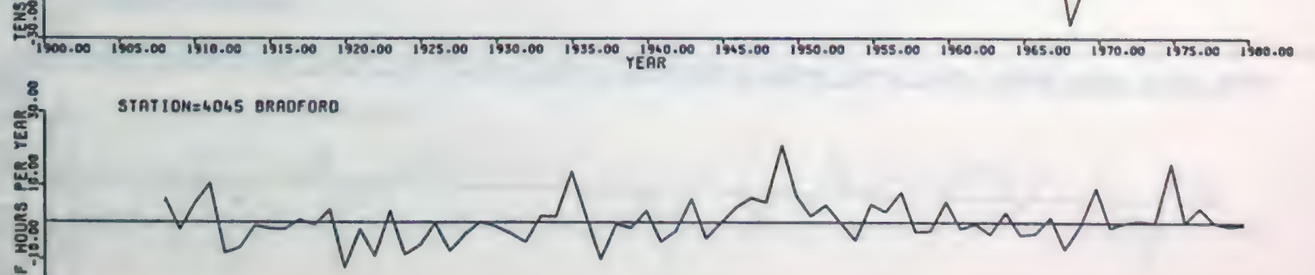
STATION=3414 WOBURN



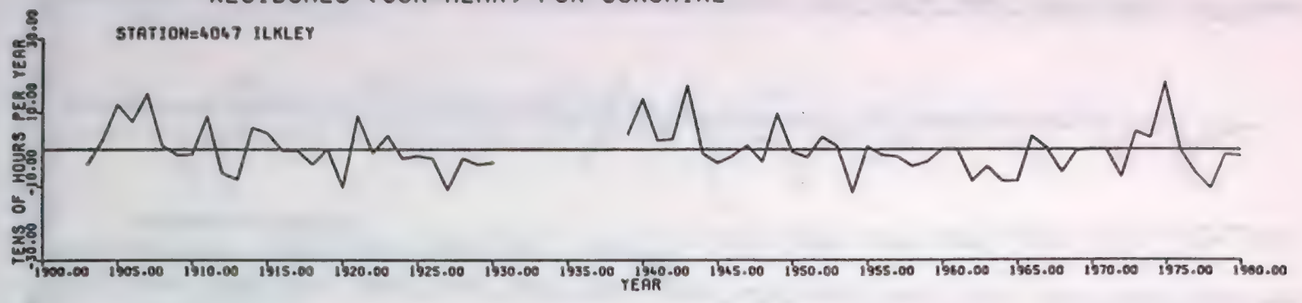
STATION=3537 ROTHAMSTED

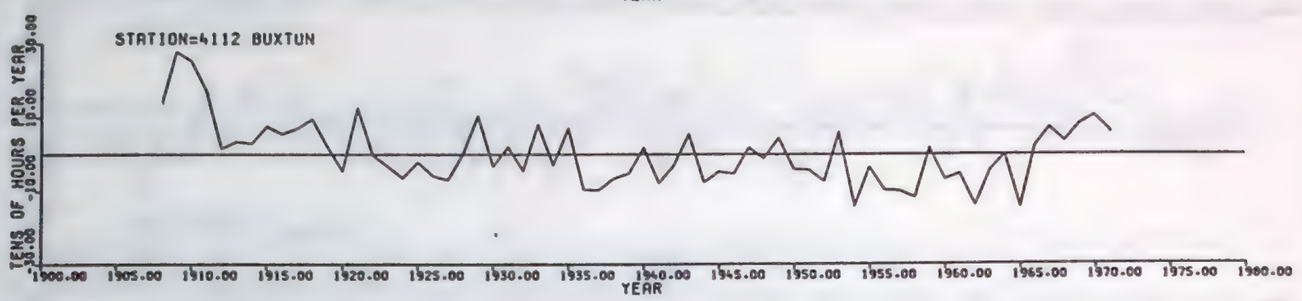


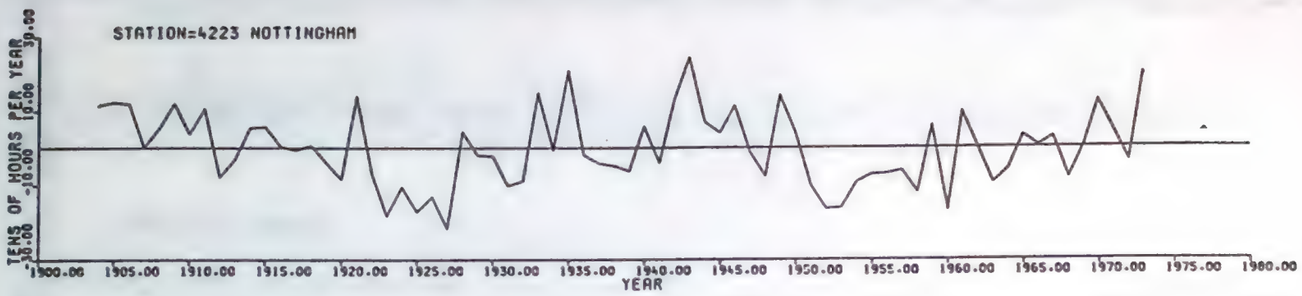
STATION=4045 BRADFORD

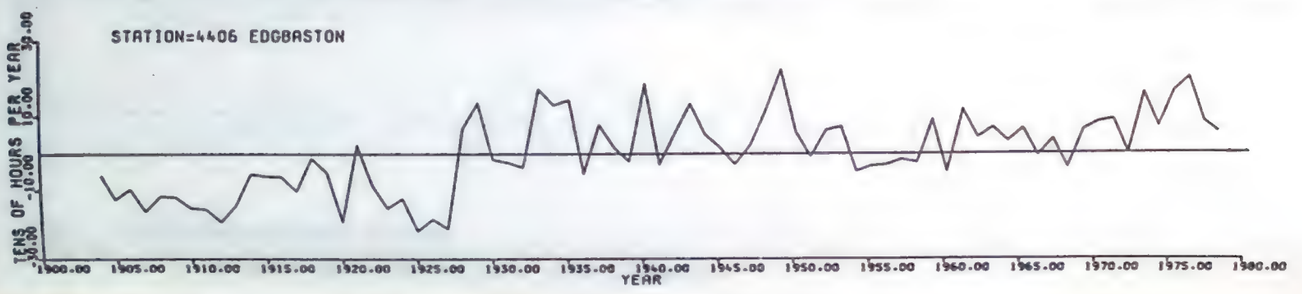


RESIDUALS (SUN-MEAN) FOR SUNSHINE

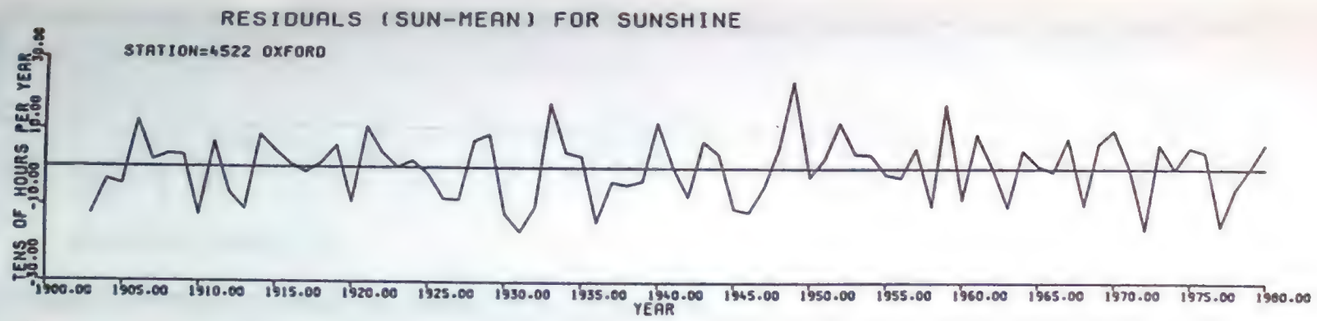


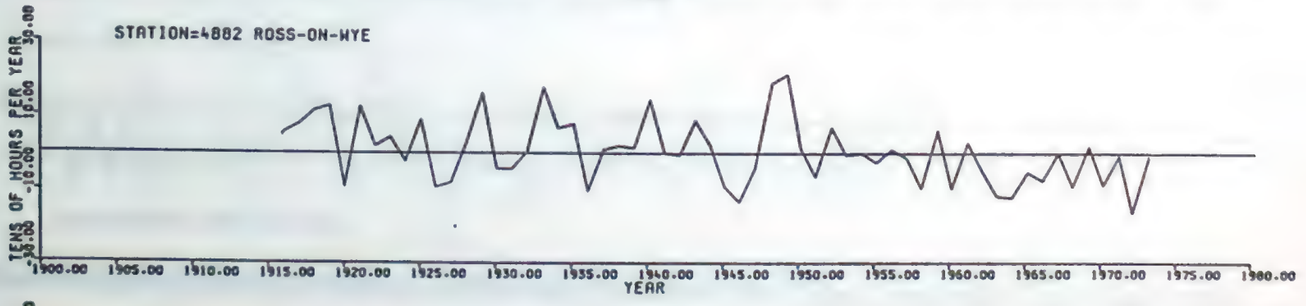


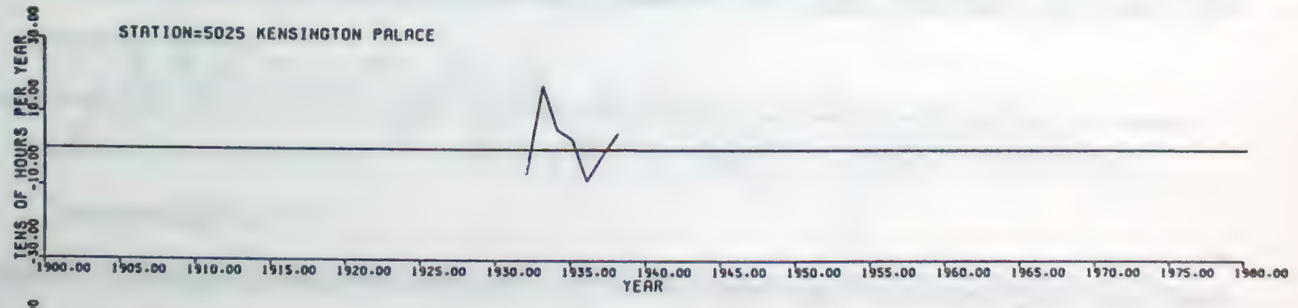


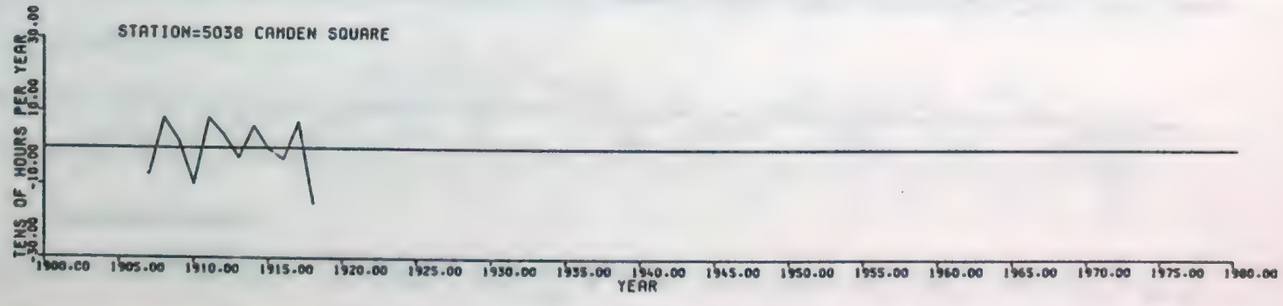


RESIDUALS (SUN-MEAN) FOR SUNSHINE

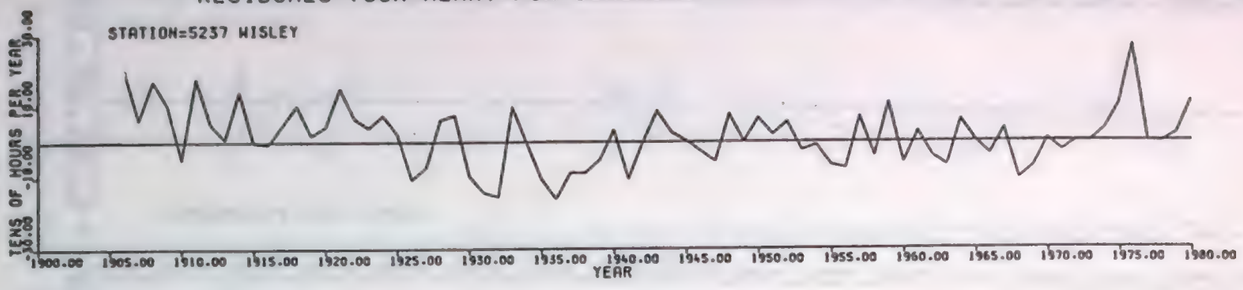


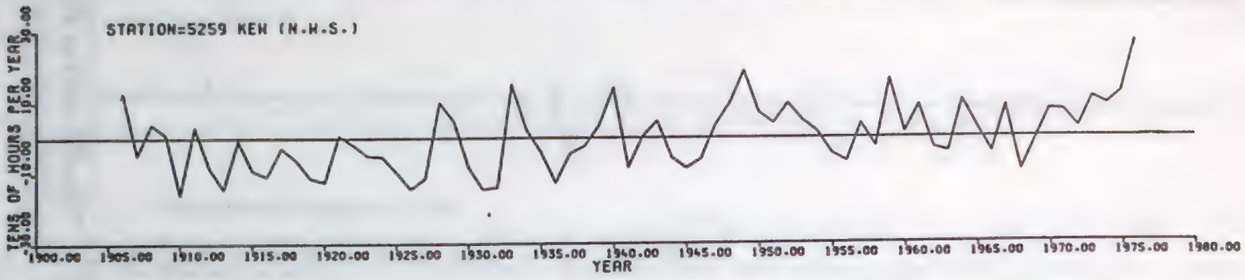


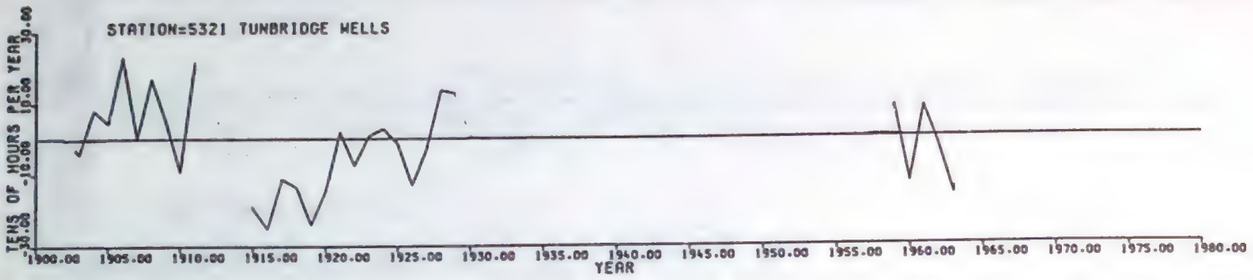


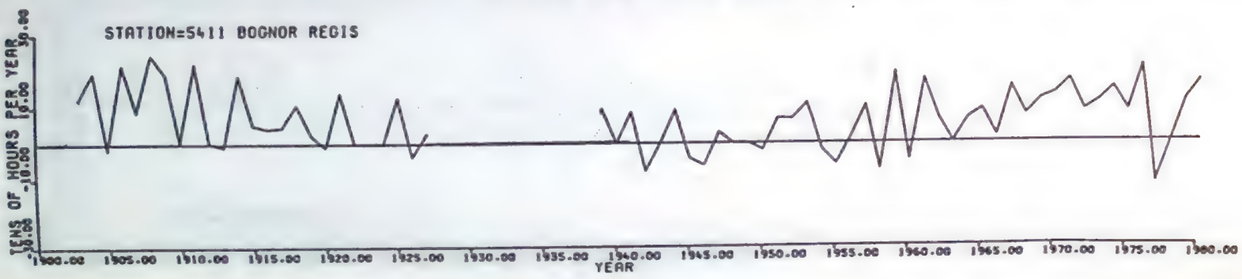


RESIDUALS (SUN-MEAN) FOR SUNSHINE

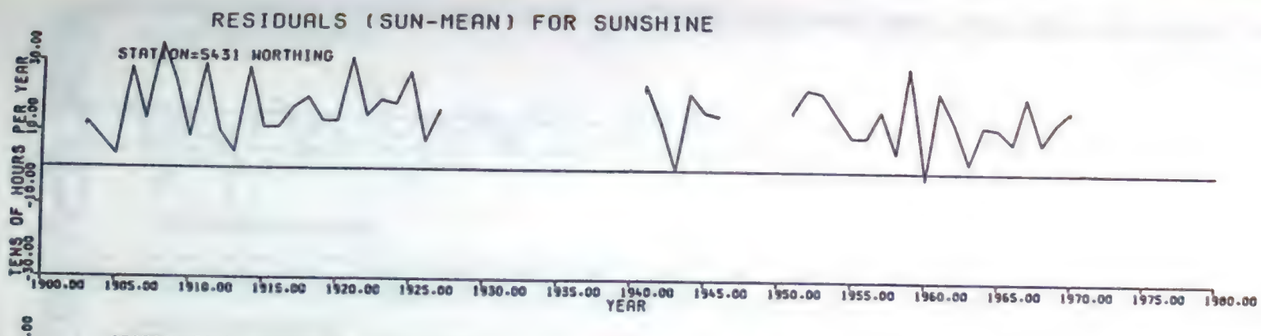


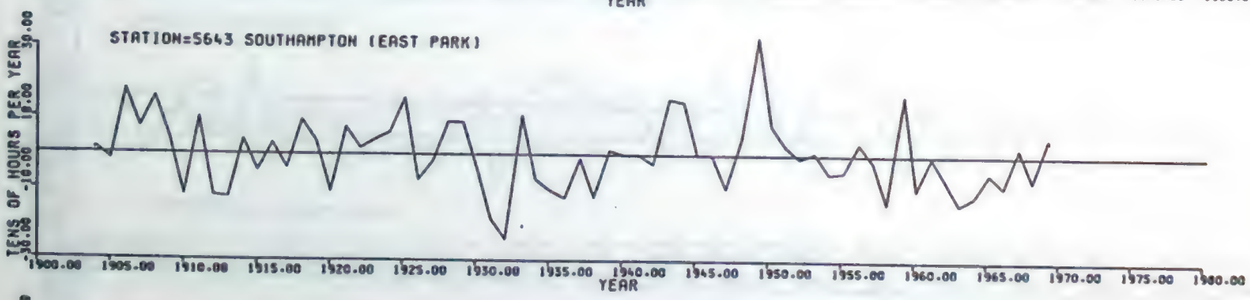


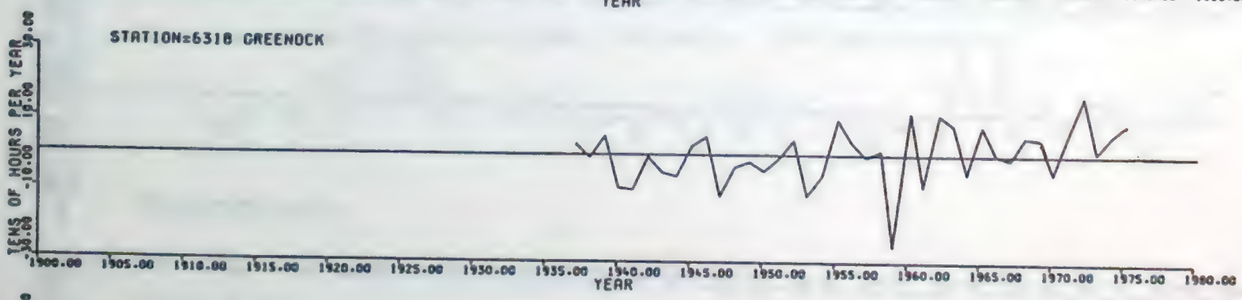


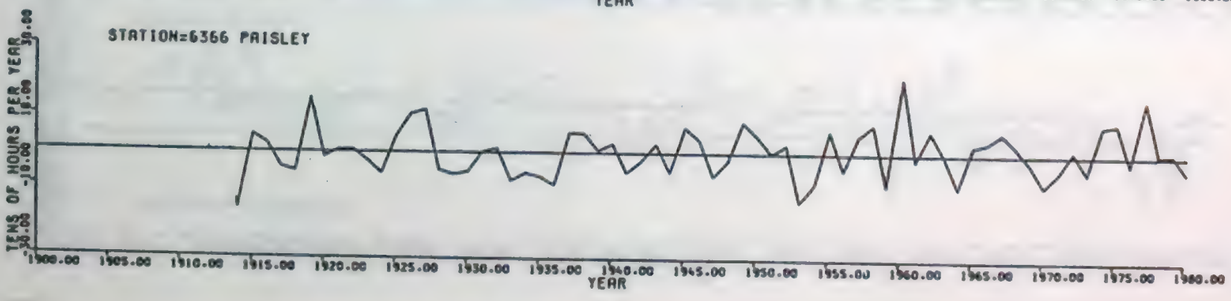


RESIDUALS (SUN-MEAN) FOR SUNSHINE

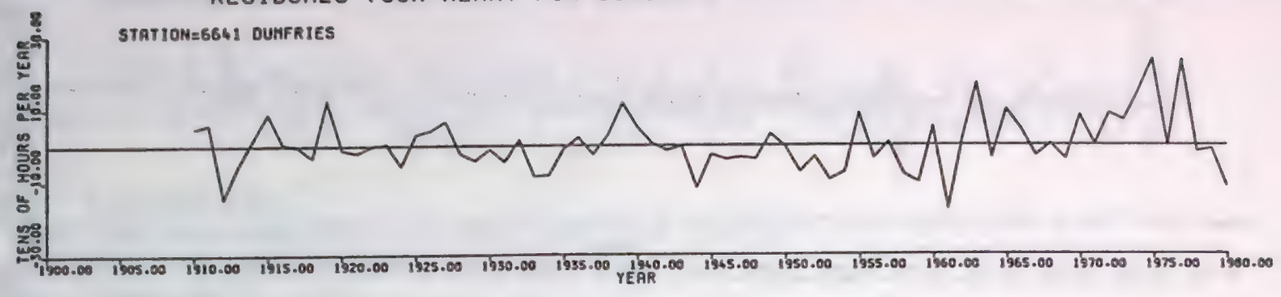


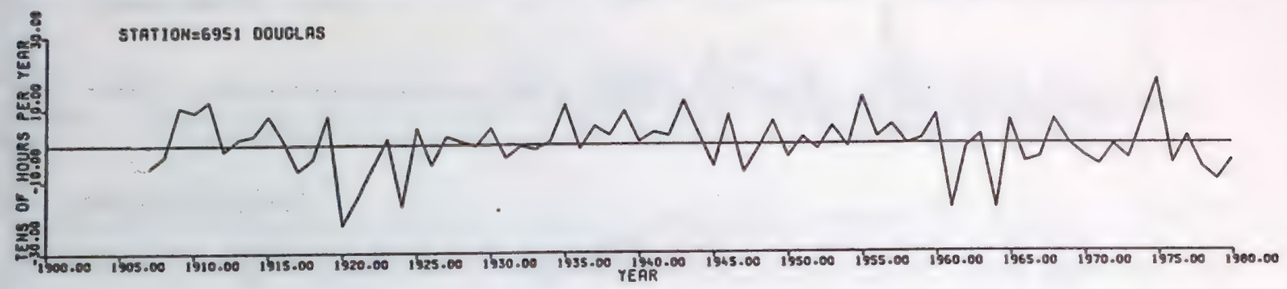


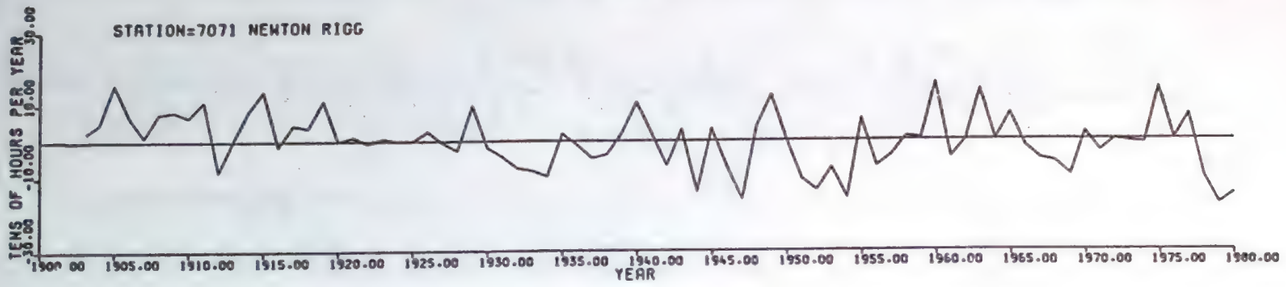


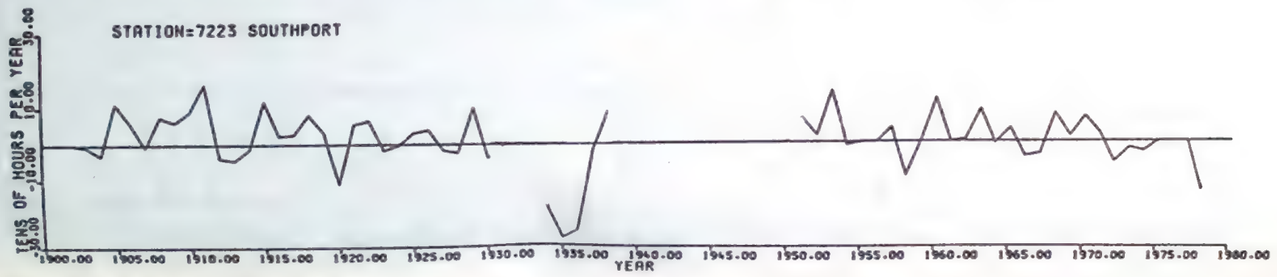


RESIDUALS (SUN-MEAN) FOR SUNSHINE

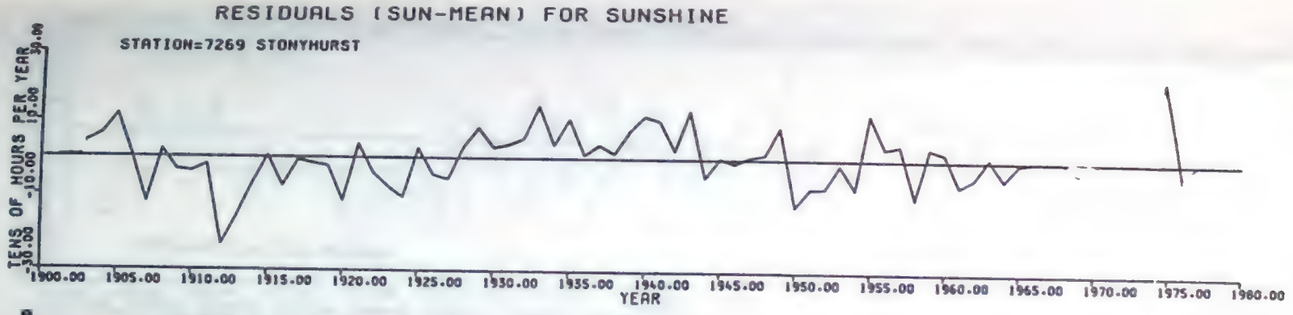


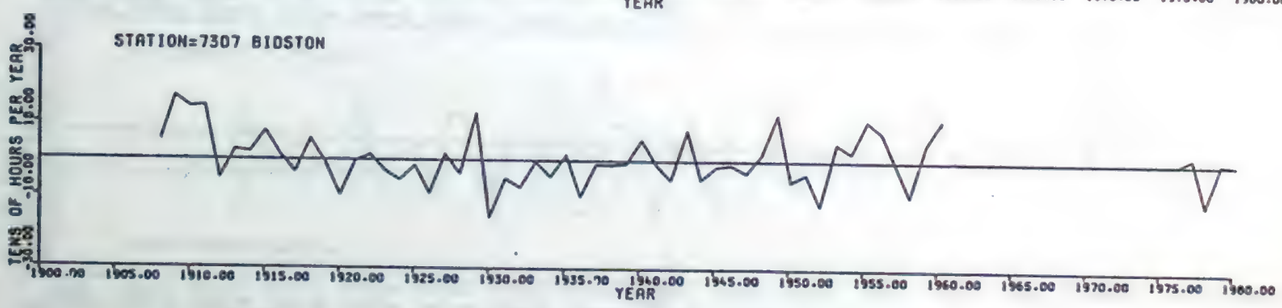




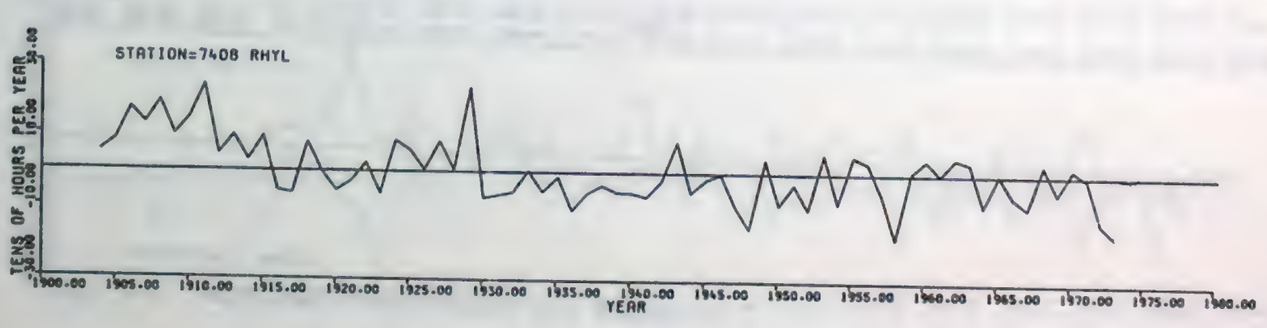


RESIDUALS (SUN-MEAN) FOR SUNSHINE



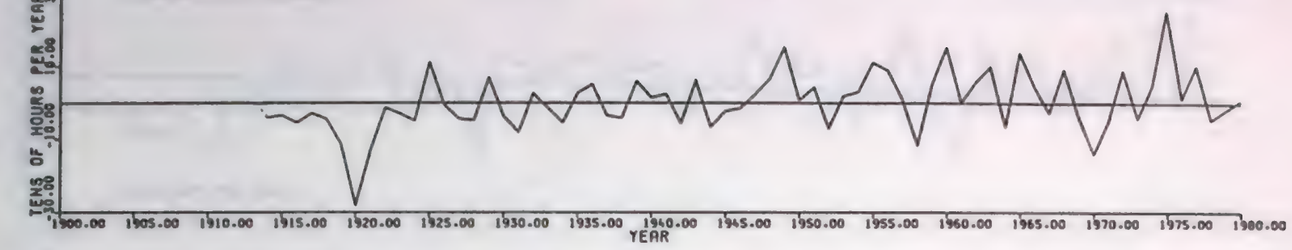


There is no sunshine data available for station 7384 (Macclesfield).

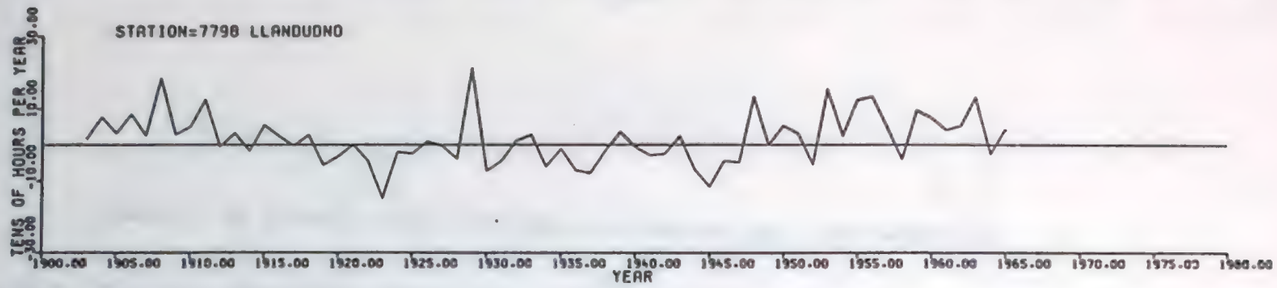


RESIDUALS (SUN-MEAN) FOR SUNSHINE

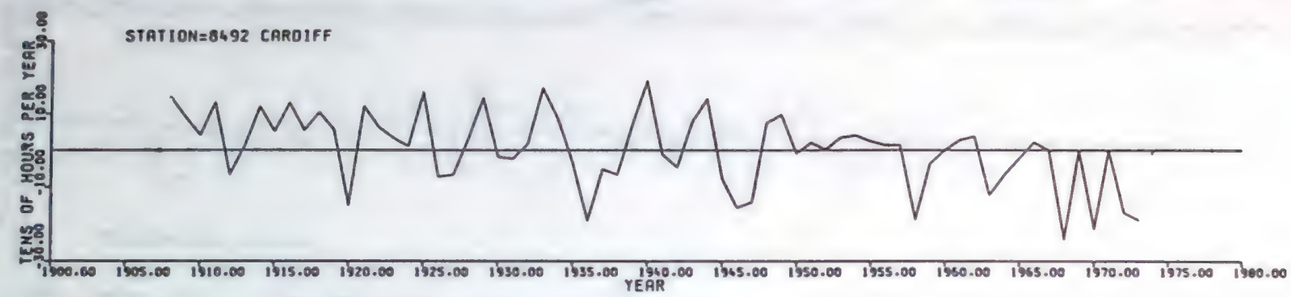
STATION=7511 VALLEY



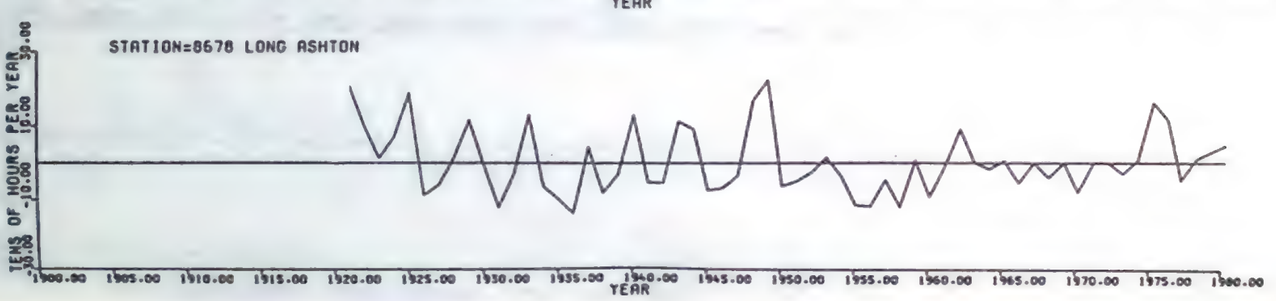
STATION=7798 LLANDUDNO



STATION=8492 CARDIFF

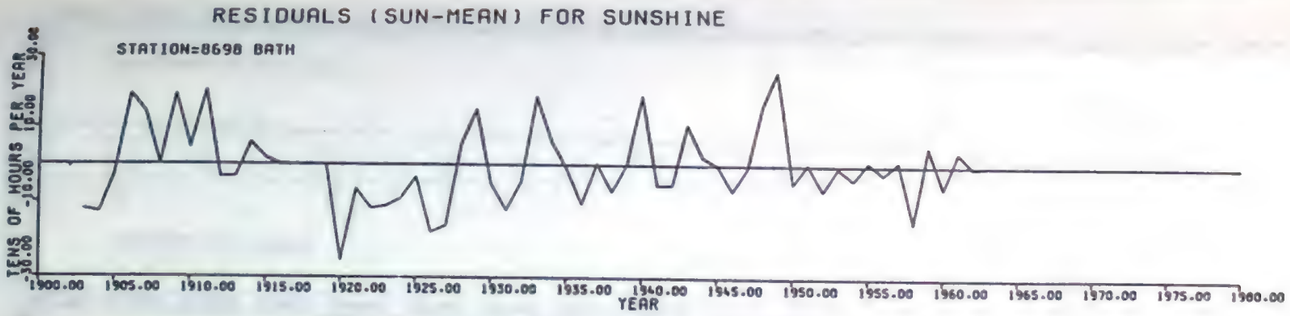


STATION=8678 LONG ASHTON

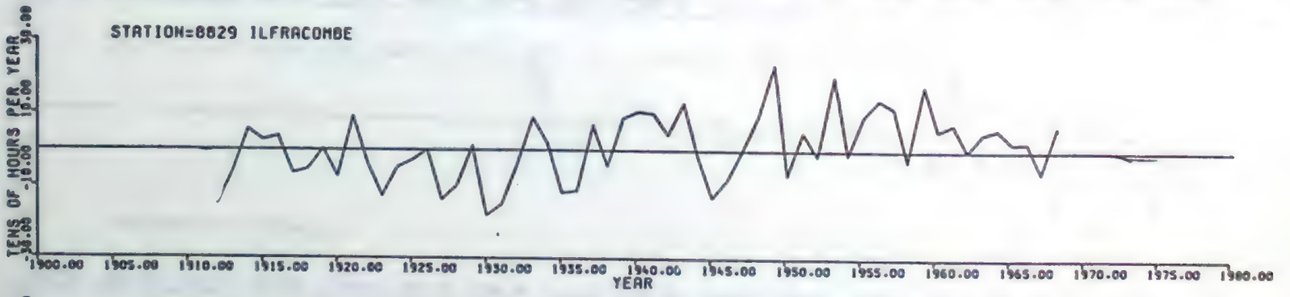


RESIDUALS (SUN-MEAN) FOR SUNSHINE

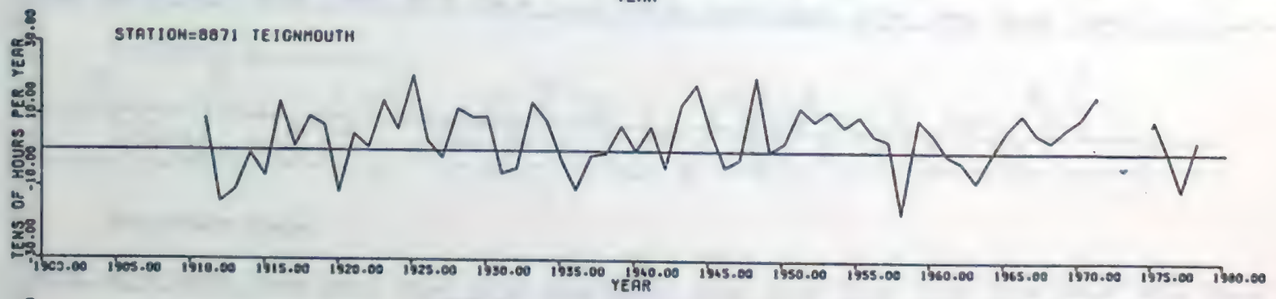
STATION=8698 BATH



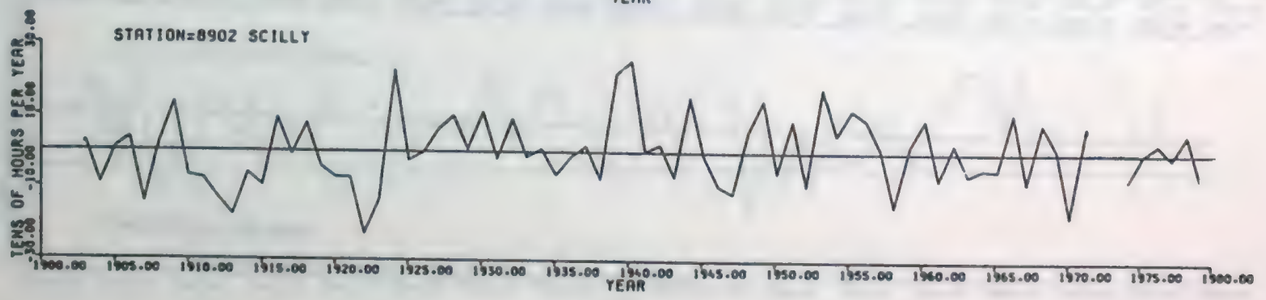
STATION=8829 ILFRACOMBE



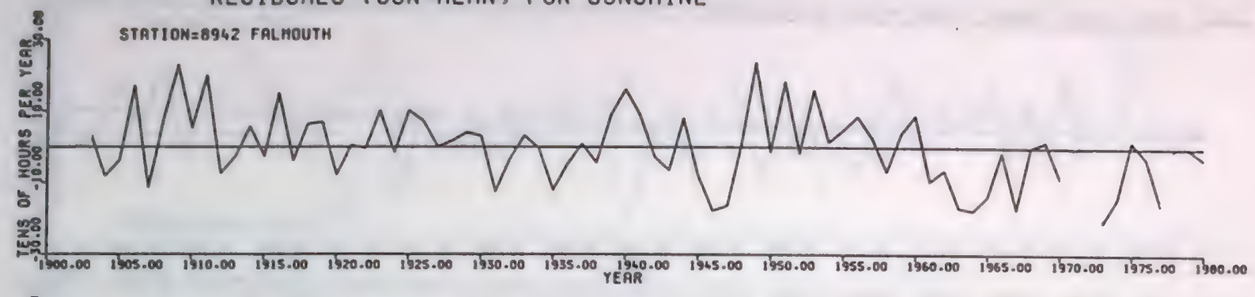
STATION=8871 TEIGNMOUTH

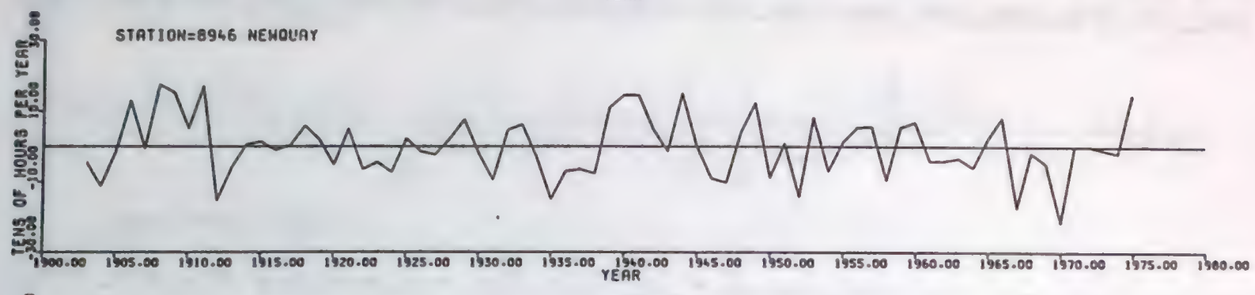


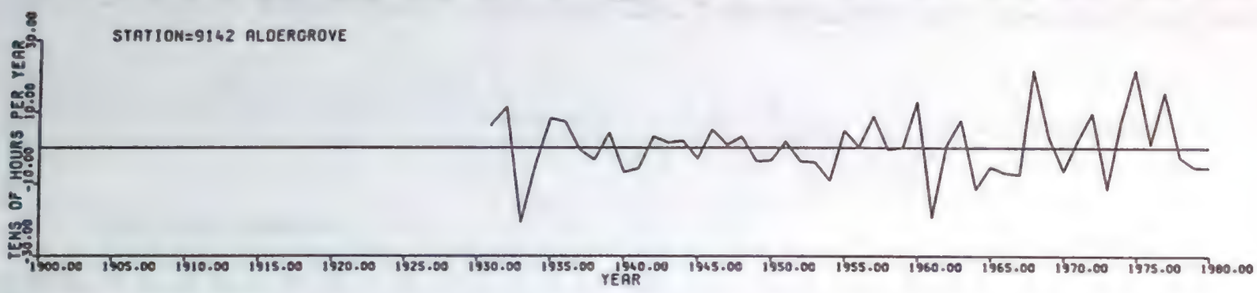
STATION=8902 SCILLY

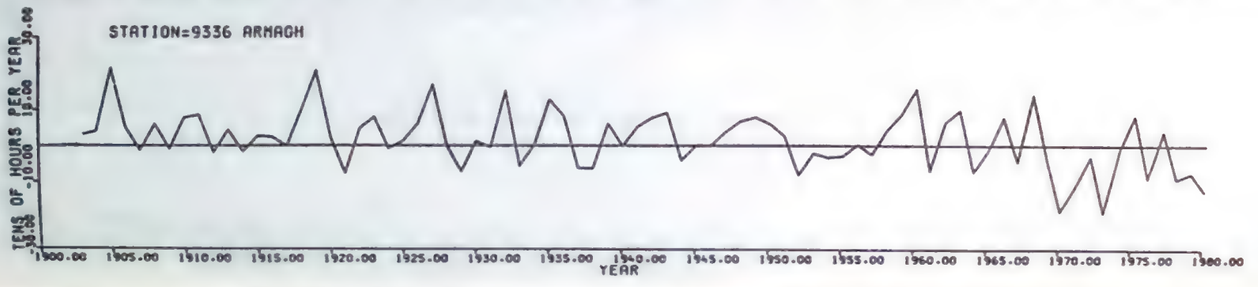


RESIDUALS (SUN-MEAN) FOR SUNSHINE

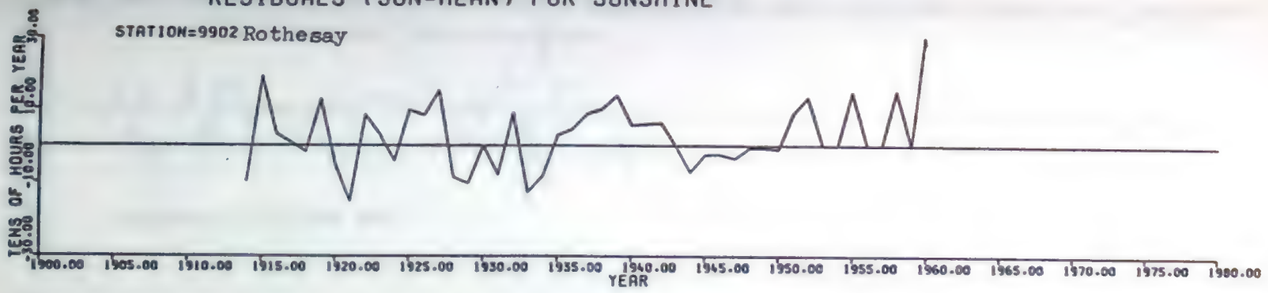




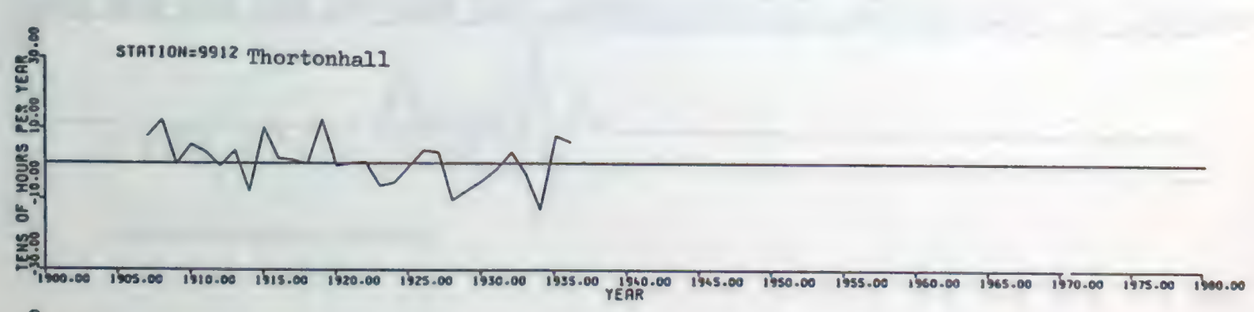


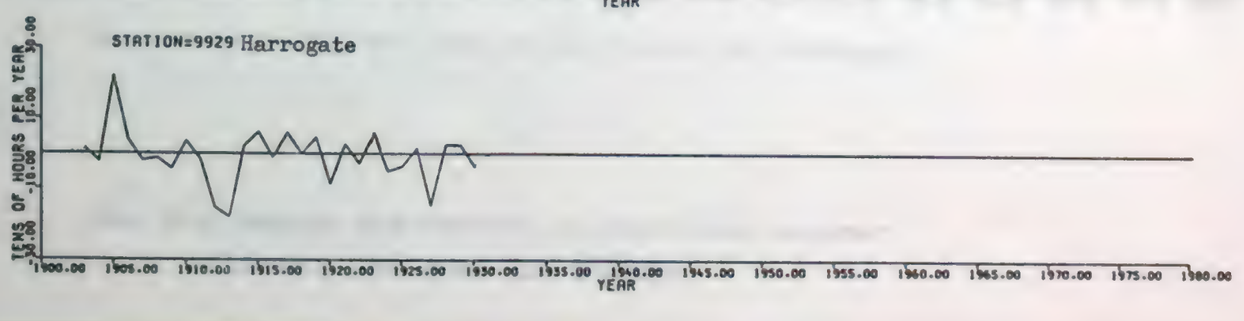


RESIDUALS (SUN-MEAN) FOR SUNSHINE

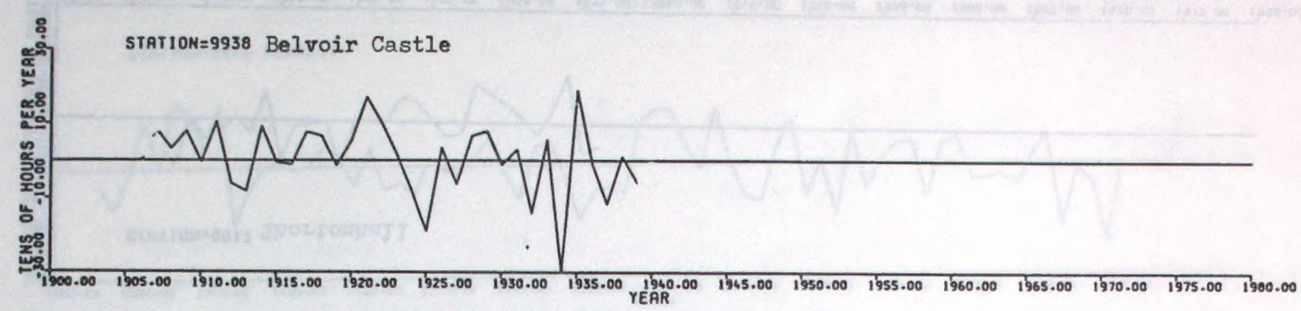


There is no sunshine data available for station 9906 (Crieff).

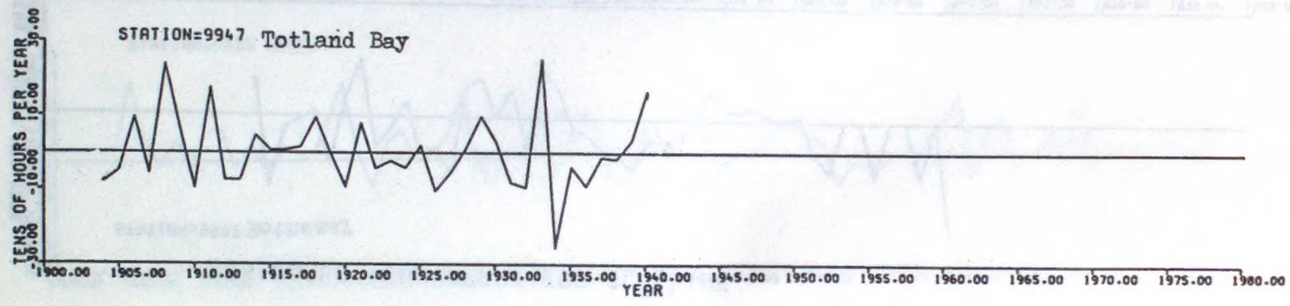




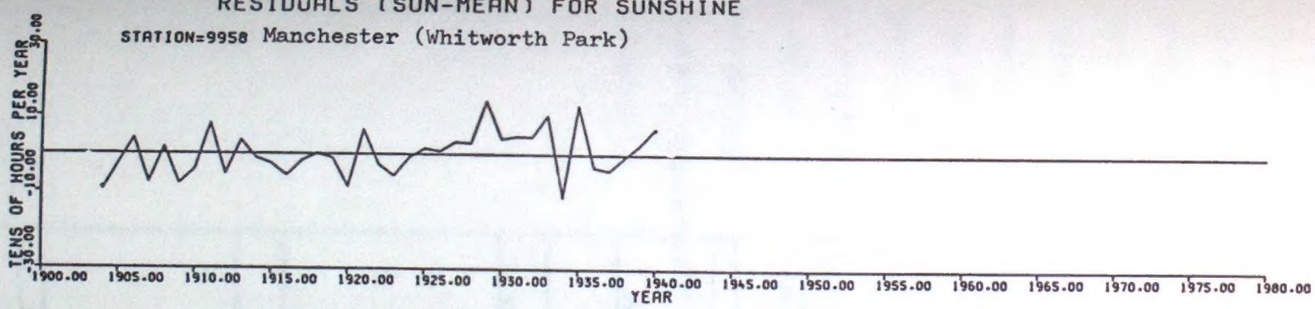
There is no sunshine data available for station 9936 (Meltham).

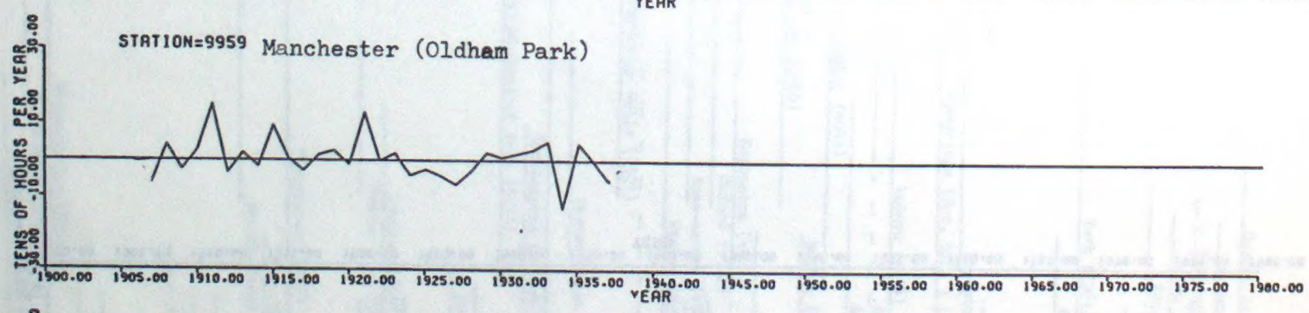


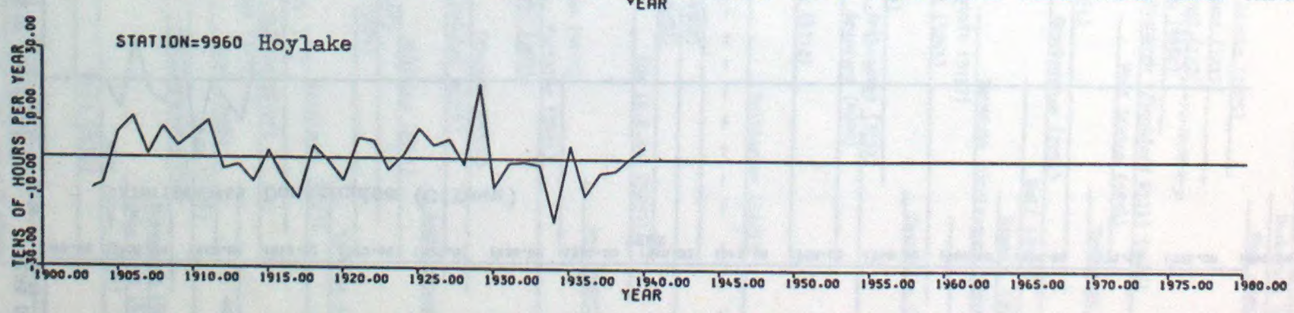
There is no sunshine data available for station 9940 (Sparkhill)



RESIDUALS (SUN-MEAN) FOR SUNSHINE







There is no sunshine data available for station 9962 (Arlington)

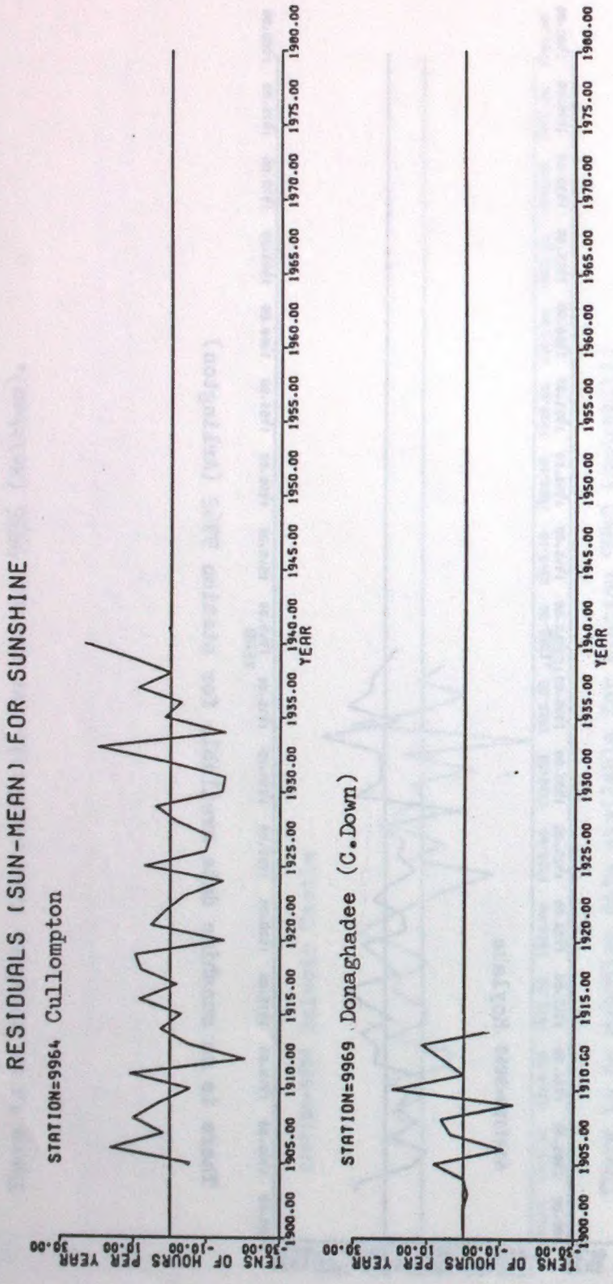


Figure 3 Summary of stations considered to contain a homogeneous period of data (excluding sunshine)

Key

—— = homogeneous

--- =homogeneous but with a slight trend in the real data (possibly due to increased urbanisation effects)

-x-x- = homogeneous with the exception of maximum temperature (Balmoral)

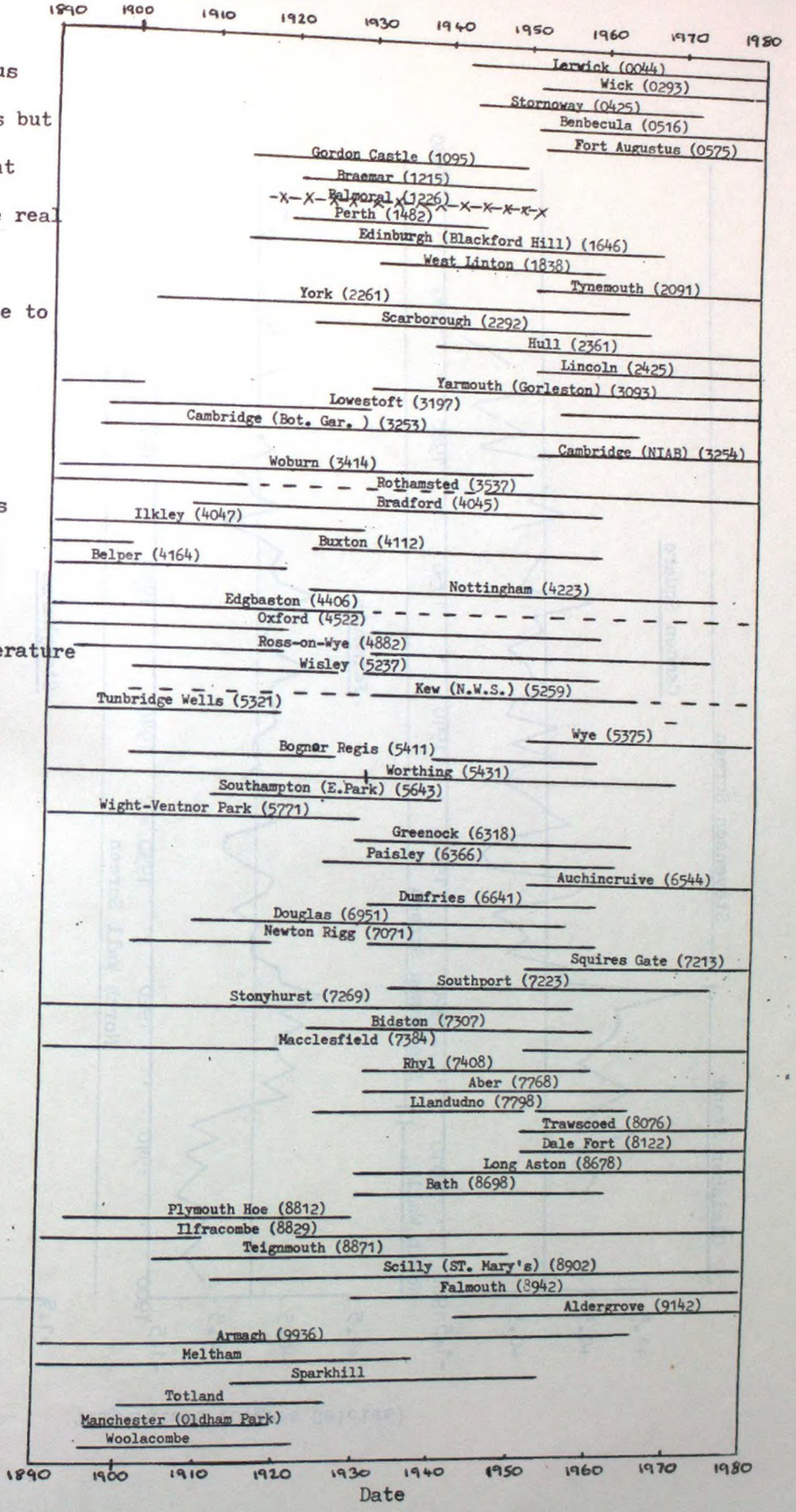
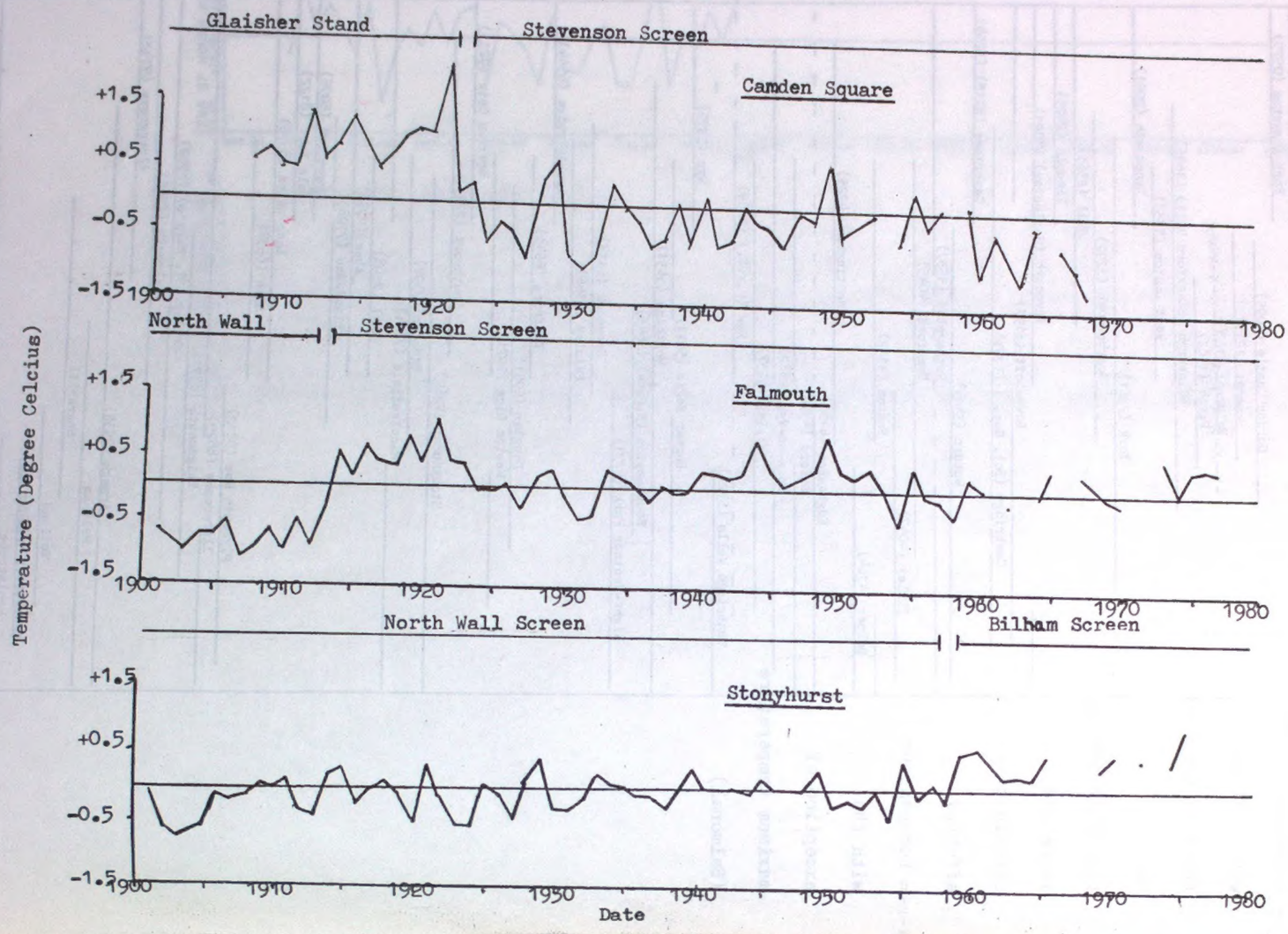



Figure 4 Inhomogeneities identified as occurring due to changes in thermometer screen